Users Manual

Artesis Motor Condition Monitor

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MCM* Motor Condition Monitor

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MCM

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Additional Information

⚠	**WARNING**
Lethal voltages and currents are present at the input terminals of this device. Accordingly, this MCM* unit should be installed and maintained only by qualified, competent personnel who have the necessary training and experience appropriate to high voltage and current devices. MCM must be used in accordance with all local and national codes for the installation and operation of electrical equipment. Observe all site-specific procedures including local lockout and tagout.	
Recommended safety precautions should be followed at all times. Both current and voltage transformers can present lethal currents and voltages when their primaries are energized and standard practices (i.e. shorting the secondaries of current transformers and removing voltage transformer fuses) must be respected during installation or any subsequent service.	
The unit is designed for operation in a control cabinet with restricted access to the rear terminals and should not be used in any environment where this is not the case. MCM should not be used for the purpose of primary protection of electrical equipment.	

Disclaimer

Maintenance planning information as well as its timing is issued based on the observations in the field and is approximate and considers the average behavior of different types of equipment. Since each piece of equipment and conditions under which it runs may be different, actual failure periods may be different. Therefore, it is recommended that maintenance actions and their timing indicated in the MCMScada Report should be used only as a guide and the indicated abnormalities should be checked and remedied as soon as feasible.

Product Disposal Statement

Customers and third parties, who are not member states of the European Union, who are in control of the product at the end of its life or at the end of its use, are solely responsible for the proper disposal of the product. No person, firm, corporation, association or agency that is in control of product shall dispose of it in a manner that is in violation of any applicable federal, state, local or international law. Artesis is not responsible for the disposal of the product at the end of its life or at the end of its use.

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1. Overview

1.1 Introduction

MCM is a revolutionary tool in the battle to keep electric motors and machinery running at peak performance, whilst maintaining high plant productivity levels. Used correctly, this unique instrument is capable of monitoring three phase AC motors of all sizes and power levels to provide clear, unambiguous indications when the performance of a particular motor (or even the machinery it is connected to) begins to degrade. The numerous transducers employed by other, less advanced instruments have been replaced by three current sensors and three voltage sensors, familiar to all those involved with the measurement of electrical quantities, making the system straightforward to install and use without in-depth training of personnel.

In addition to its unique capabilities as an intelligent condition-monitoring device, MCM can also perform many of the functions of, and indeed replace the more traditional energy monitoring and data-logging instruments.

For applications involving the monitoring of many motors and associated machinery, the networking options available with MCM allow units to be connected together to a host terminal where they can all be viewed together.

Furthermore, the monitoring software package allows examination of the various parameters MCM uses to determine the status of a motor and to trend the parameters as a visual indication of degradation over time.

Despite its simplicity and ease of use, like any intelligent electronic, software-based device, it is important that MCM is installed and used correctly. We strongly recommend that you take the time to study the information contained within the accompanying manuals and to familiarize yourself with the operating principles and practices.

1.2 Use of this manual

This manual explains the basic concepts needed to install and use MCM. The appendix at the end of the manual provides information that may be useful to the general user. For further, specific details please contact Artesis.

2. MCM Installation

2.1 Preliminary checks

Please inspect the contents of the MCM package and ensure that they agree with the information in the packing list. In the event of any missing or damaged items, please contact your supplier immediately. Check also that the power range of the MCM unit is suitable for the motor to be monitored. The device type can be found on the MCM label. Artesis will not accept responsibility for damage caused to or by any MCM unit that has been incorrectly installed or installed on a motor system outside the indicated power range.

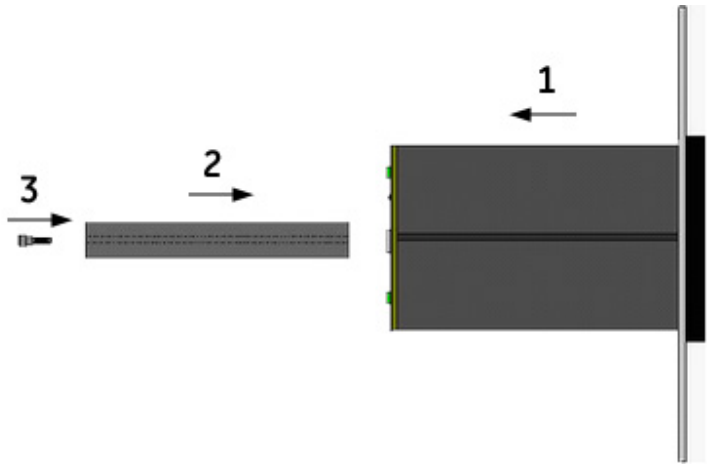
2.2 Safety Notes

⚠	**WARNING**
	HAZARDOUS VOLTAGE Can cause death or serious injury. Multiple energy sources present. See user manual before servicing. Turn off and lock out all power supplying this device before working on this device. If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

2.2.1 Safety related symbols on the device

	Risk of electric shock
	General warning symbol

2.3 MCM Unit Installation



NOTE
MCM has been designed to mount directly onto the front panel of the motor switchgear cabinet. Any other usage is not recommended due to the lethal voltages present at the terminals.

To mount, insert the MCM unit into the prepared 3.62x3.62 inches (92x92 mm) cutout on the cabinet panel 0.97 inches (5 mm) panel thickness and push until the front of the unit is flush with the panel. Insert the side retainers and tighten the thumbscrews on each retainer until the MCM unit is held securely in place.

⚠	WARNING
In common with any device connected to high power electrical supplies, only suitably qualified personnel should install and maintain MCM.	

2.4 Current Transformer (CT) and Voltage Transformer (VT) Installation

⚠	**WARNING**

All installation, wiring and periodic maintenance of MCM well as its associated circuits involves high voltages and currents. While this manual suggests several safety and reliability steps, it must be used in conjunction with the safety codes in force at your location. Failure to practice safe working procedures is likely to cause damage to the installation, severe injury and / or death. All work including handling of electrical circuits during Installation, wiring and periodic maintenance must be done only by qualified personnel.

Neither Artesis nor its agents may be held responsible for damage or death arising out of the wiring and / or VT, CT or other external circuits.

Current and voltage transformers must meet local standards and regulations. For North America, current and voltage transformers must be certified by an OSHA appointed NRTL to appropriate UL or CSA - product safety standards.

WARNING

CURRENT TRANSFORMERS

Incoming power must be de-energized before installation. Before wiring, de-energize the CT secondary by shorting it via a shorting block.

The current transformer must have its secondary terminals short-circuited or connected to MCM unit, before energizing the primary circuit.

Under no circumstances must the CT secondary be left open-circuited, even momentarily, when primary current is flowing. This causes high voltages that will overheat and explode the secondary of the CT and damage the instruments as well.

Before disconnecting any MCM unit to or from a current transformer, the secondary terminals of the transformer should be shorted using a link capable of carrying several times the nominal output current (i.e. at least 10A).

WARNING

VOLTAGE TRANSFORMERS

Incoming power must be de-energized before installation.

Never short-circuit the secondary terminal of a voltage transformer even this is not in use. A secondary short-circuit will cause the unit overheat and fail in a very short period of time.

Before wiring, de-energize the VT secondary by opening the circuit or removing the fuse. Do not short the VT secondary.

Before performing any work on a voltage transformer, its fuse must be removed or switch opened.

Use a 1 Amp fuse on each voltage input.

2.4.1 Low voltage line driven systems

Three standard 5A secondary, current transformers of appropriate ratings are recommended for current sensing (please refer to the appendix at the end of this manual for full specifications). The secondary terminals of each transformer should be connected to the corresponding current measurement terminal pairs, **I_{11}-I_{12}**, **I_{21}-I_{22}**, **I_{31}-I_{32}**, on the rear of the MCM unit.

Voltage line connections V_R, V_S, V_T should be made directly to their respective voltage measurement terminals **V_1**, **V_2**, **V_3** at the rear of the unit.

Please refer to the connection diagrams in the appendix at the end of this manual for further details.

2.4.2 Low voltage inverter driven systems

The current sensors employed by MCM for inverter driven systems are Hall-effect type requiring an external DC power supply. The motor current rating should be checked carefully to ensure compatibility with the sensors provided. Please refer to the appendix at the end of this manual for further details on sensor selection.

High current sensors (for currents greater than 200 A) need to be mounted separately at a convenient location within the switchgear cabinet together with their external power supplies. Smaller sensors are mounted on the same circuit board as the power supply and should be placed together at the chosen location. In both cases, the cable carrying power to a single phase of the motor must be passed through the central hole in the appropriate current sensor and secured.

The power supply ground should be connected directly to the **I_{12}**, **I_{22}**, **and I_{32}** pairs of current measurement terminals on the rear of the MCM unit.

Voltage connections V_R, V_S, V_T should be made directly to their respective voltage measurement terminals **V_1 V_2 V_3** at the rear of the unit.

NOTE
MCM is not recommended for use with inverters operating at a chopping frequency lower than 2 kHz.

Please refer to the connection diagrams in the appendix at the end of this manual for further details.

2.4.3 Medium/High voltage systems

Three standard 5A secondary, current transformers of appropriate ratings are recommended for current sensing (please refer to the appendix at the end of this manual for full transformer specifications). The secondary outputs from each transformer should be connected to the corresponding current measurement terminal pairs, **I_{11}-I_{12}**, **I_{21}-I_{22}**, **I_{31}-I_{32}**, on the rear of the MCM unit.

⚠	**WARNING**
If compensation capacitors are employed, it is essential that the current transformers be placed between the motor and the capacitor bank so that only the true motor currents are measured.	

Standard 100V, 110V and 120V secondary voltage transformers should be used to drop the voltage to usable levels. Connections from the secondary outputs of the transformers should be made to the respective voltage measurement terminals **V_1**, **V_2 V_3** at the rear of the unit.

Please refer to the connection diagrams in the appendix at the end of this manual for further details.

2.5 Rear panel connections

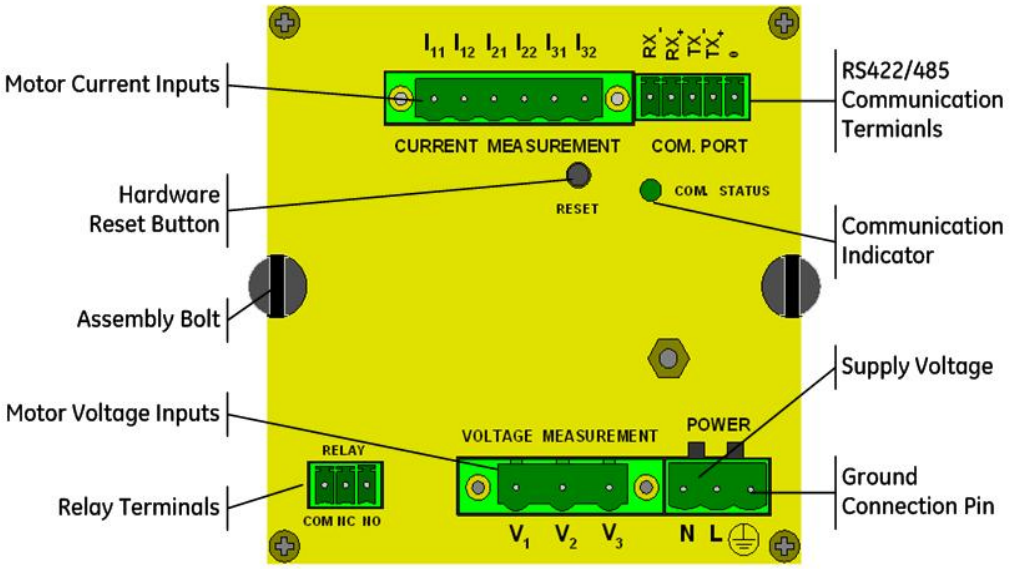
Connections to the MCM rear panel are given in the following figure. Lethal voltages can be present at the voltage and current terminals and it is vitally important that power is removed from both the motor and the MCM unit prior to any connections being changed.

⚠	**WARNING**
Remove ALL power prior to changing connections. Multiple Energy sources present.	

The three motor power voltages should be connected to the corresponding measurement terminals on the MCM rear panel (R phase to **V_1,** S phase to **V_2**, and T phase to **V_3**) using the connectors provided. Similarly, the I_R, I_S, I_T connections from the current sensors should be made to the appropriate current terminal pairs, **I_{11}-I_{12}**, **I_{21}-I_{22}**, **I_{31}-I_{32},** on the upper part of the rear panel.

NOTE
It is not essential that all three sets of phases have the correct phase relationship as the phase ordering is determined by MCM.

The order of these voltage and current pairs is not important as MCM determines the correct ordering when **CHECK MOTOR** is first run on the device.



2.5.1 Protection against pickup of electromagnet interference on the power lines

In order for the unit to function within the harsh electrical environments often found in switchgear enclosures and to conform fully with emission standards, it is strongly recommended that all attached cables be passed through the ferrite rings delivered with the product to their MCM sockets.

NOTE
A circuit breaker should be provided on the power line in close proximity to the MCM unit. The circuit breaker should be clearly marked as the power switch for the device. The equipment should not be positioned so, that it is difficult to operate the disconnecting device.

NOTE
Please note that in order to function at its full capability, MCM requires that the case be connected using a low impedance cable (12 – 14 AWG cable is recommended) directly to a high quality ground via the ground terminal on the power connector. If a suitable ground is not provided, fault free operation within specifications cannot be guaranteed.

2.6 Applying power to the MCM unit

Once the motor connections have been made to the rear panel, power should be applied to the unit. MCM requires between 100 and 240VAC obtained from a single phase, neutral and ground. At this stage, the **Power** indicator at the left of the front panel will light. If this does not occur, please check that the correct voltages have been applied.

Immediately on application of power, the LED condition indicators should briefly flash and activity should be seen on the main display. The text "Initializing" followed by a series of dots will appear.

"Initializing....."

After a few seconds, the display should indicate that it is in the **IDLE** mode. MCM is now ready for use. When using a device for the first time the message "Bad flash data! Press Clear" may be displayed. In this case press the CLEAR button several times until the message disappears. Once a valid learn mode has been completed, this message should not occur again.

2.7 Installing with soft-starter systems

MCM can be installed with standard soft-starter systems provided that they are automatically bypassed immediately after motor start-up and during subsequent use. Un-bypassed, soft-starter systems can introduce considerable distortion into the current waveforms and thus prevent MCM from modeling the properties of the motor itself. If MCM is to be used with such a system, it is essential that the maximum current limit of the starter be above the nominal running motor current so that it is bypassed effectively during all normal operation.

NOTE
MCM should never be used on a system that employs soft-starters for speed control or other un-bypassed uses.

Please refer to the diagrams in the appendix for details of the connections needed for soft starter systems.

NOTE
Soft-starters should always be bypassed.

2.8 Installing with inverter drives

Using MCM with inverter driven motors requires the same voltage connections specified for line driven systems. External Hall-effect current sensors must be used with inverter systems, as normal current transformers have insufficient bandwidth for use with the range of frequencies obtainable from inverters. Please refer to the diagram in the appendix for details of the connections needed for inverter driven systems.

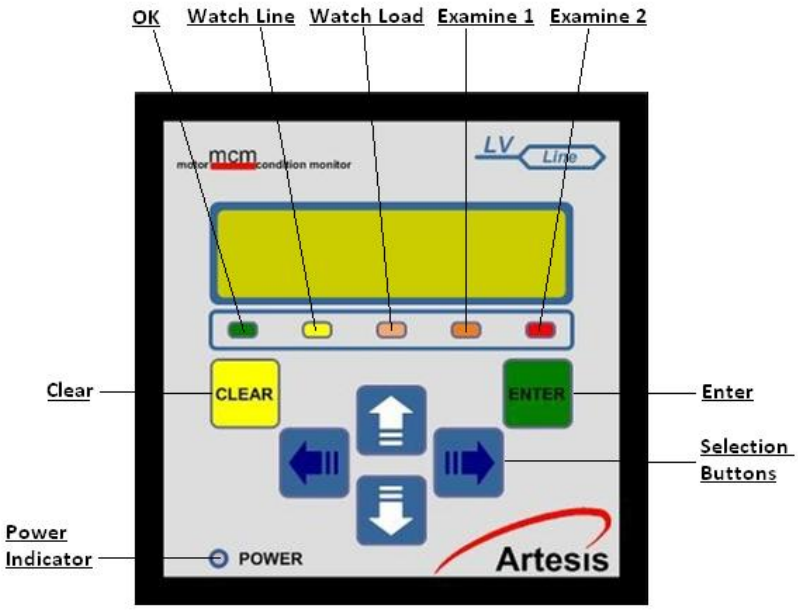
3. MCM Use

3.1 Introduction

Use of MCM is both simple and straightforward once the basic concepts and principles are understood. This section of the manual is designed to introduce these concepts and to demonstrate how MCM is set up, how to check all the connections and settings, how MCM learns the characteristics of the system it will monitor and finally how to actually monitor the motor system. It is recommended that first time users read this section carefully, as successful operation requires that MCM is set up and used correctly.

Flowcharts for the main operations are provided in the appendix at the end of this manual to help users navigate their way through the various steps involved with setting and running MCM for the first time.

3.2 The front panel

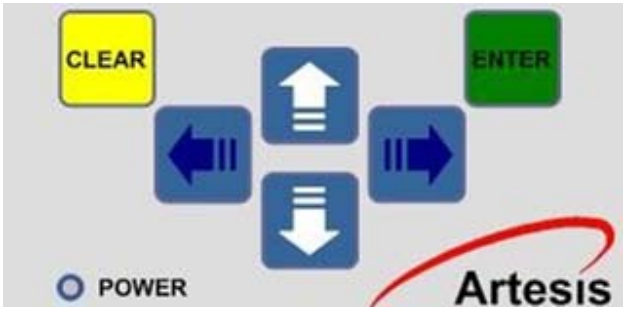


3.2.1 Confirming ENTER and CLEAR

Once the sensors have been connected and power has been applied to the MCM unit, the **Power** indicator light and the Liquid Crystal Display (LCD) on the front panel should both be lit. The LCD should display the message **IDLE** on the top line, indicating that the unit is idle and waiting input from the user. When being used for

the first time, the message ''Bad flash data! Press Clear'' may be displayed. The user should repeatedly press the **CLEAR** button until the message disappears. Once data has been written to flash this message should not occur again.

3.2.2 Using the front panel buttons



Commands are input by pressing one of the six selection buttons on the front of the unit: **UP**, **DOWN**, **LEFT**, **RIGHT**, **ENTER** and **CLEAR**. For instance, the user can cycle through the various modes (IDLE to CHECK MOTOR to RUN to RESUME … and finally back to IDLE), by repeatedly pressing the **UP** button. A particular mode can be selected by pressing **ENTER** when the desired mode is displayed on the LCD. The menus are set up on a hierarchical basis, with each level representing commands of the same precedence which the user can cycle through by pressing the **UP** or **DOWN** buttons. Pressing **CLEAR** has the effect of stopping a particular action and rising up a level in the hierarchy. Only **Edit Settings** has nested hierarchy levels more than two deep. In general, whenever **ENTER** or **CLEAR** is pressed, it will be necessary to confirm the action with a second press of the button; pressing the other button (i.e. **CLEAR** after **ENTER** and **vice versa**) will cancel the action.

3.2.3 Setting numeric values

Similarly, numeric values can be entered using the arrow buttons. When a value is to be changed, use the **LEFT** or **RIGHT** buttons to move the LCD flashing cursor to the first digit to be edited and repeatedly press either the **UP** or **DOWN** buttons to scroll through the available alphanumeric characters until the desired one is displayed. Subsequent digits can be edited by moving to the next digit using the **LEFT** or **RIGHT** buttons and again scrolling with the **UP** and **DOWN** buttons. A schematic diagram showing the menu hierarchy is shown in the appendix at the end of this manual.

3.3 Configuring for use

3.3.1 Master reset

When first installed the MCM unit will be configured for the default factory settings, which will need to be changed prior to use. At later times, the factory settings can

be restored by pressing and holding down the **LEFT** button for about 4 seconds during power up of the device, until the string ''Press ENTER'' for general reset appears. At this stage pressing **ENTER** will initiate the reset. Pressing any other button will cause the reset to be ignored and the device will continue.

3.3.2 Entering the password

To configure the unit, select the Edit Settings mode and press and confirm **ENTER**. In order to proceed further, it will be necessary to enter a password.

NOTE
The factory setting for this password is the string “m“ and can be entered using the UP and DOWN buttons to cycle through the alphanumeric characters (‘a’ through ‘z’, ‘0’ through ‘9’).

The **LEFT** and **RIGHT** buttons are used to shift the active character in the string. To input the password “m”, repeatedly press the **UP** button until the letter ‘m’ appears in the first position. Press and confirm **ENTER** and then press **ENTER** again to enter the Edit Settings menu.

It is recommended that at a later time the password be changed, in order to prevent unauthorized access to the device.

3.3.3 The Edit settings menu

At this level the following Edit Settings menu items are accessible:

Motor values	Alarm thresholds
Harmonic values	Versions
Comm. settings	Run settings
Motor settings	Phase Ordering
Calibration	Change password

Editing and displaying menu items

Please refer to the appendix for a table of these menus and their sub-menu items. To edit a particular item, first select the item to edit and press and confirm **ENTER**. As before use the **UP** and **DOWN** buttons to scroll vertically through individual digits and the **LEFT** and **RIGHT** buttons to change the digit being edited. Some variables can only take discrete values represented by character strings and in this case vertical scrolling will shift through the allowed values. For example, the Parity value under the Communications settings menu can only have the values EVEN or ODD and scrolling will repeatedly cycle through these values.

Menu Paths

Throughout this manual, paths to menu items are represented by the word MENU: followed by the list of sub-menus required to reach the item separated by a forward slash. For example, the path of the Parity value given in the preceding paragraph would be given as:

MENU: Edit Settings / Password / Comm. Settings / Parity

The forward slash can be thought to represent the action of pressing and confirming **ENTER**.

Local Lockout and passwords:

Some modes can be protected for supervised access by setting the local lockout setting.

MENU: Edit Settings / Password / Run Settings / Local Lockout

If this mode is set, access to the following modes is password protected:

1. CHECK MOTOR
2. RUN
3. RESUME
4. UPDATE

In addition, canceling any of these modes by pressing **CLEAR** also requires the user to supply a password. All passwords are the same as that used to access Edit Settings.

3.3.3.1 First time use

Before MCM can be used for the first time it is necessary to change various settings from their default values (a table outlining the MCM settings is shown in the appendix). Values relevant to the connected motor must be set for the quantities described in the following sections.

3.3.3.2 Calibration factors

Hall-effect current sensors and assemblies supplied with MCM should be accompanied by a calibration document containing the sensor's calibration factor. The values of each calibration factor should be entered into the correct setting under the **Calibration** menu. It is important that the correct factor be entered for each channel, as MCM will not function correctly if the calibration factors are incorrect.

For channels connected to transformer sensors, the calibration factor should be equal to the nominal ratio of the primary to secondary turns. For example a 100A current transformer with a 5A output and a single primary turn would require a calibration factor of 20. The same transformer with two primary turns would require a calibration factor of 10. A 6500V voltage transformer with a nominal secondary voltage of 100V would require a calibration factor of 65.

NOTE
Any channel connected directly to the motor without an external sensor (i.e. voltage connections on low voltage units) requires a calibration factor of 1.

3.3.3.3 Motor settings

Nominal voltage, current and frequency:

The nominal voltage, current and speed (in rpm) of the attached motor must be entered under the **Motor Settings** menu. These values can be obtained from the motor specifications. MCM uses these values to determine whether the motor complies with its specifications and incorrect values are likely to raise alarms. The nominal line frequency (or most commonly expected frequency in the case of an inverter) should also be set. Similarly, the motor connection type must be set to one of **Star** or **Delta.**

3.3.3.4 Communication settings

Setting the device address:

If the MCM networking options are to be used, the MCM network address must be supplied. By default this is set to 0, which by convention is the address of the host terminal. Use of this address will therefore disrupt communications over the network and must be changed prior to connection. Any address between 1 and 255 can be selected although it is important to check that the selected address is not in use by any other device on the same node.

It is recommended that the motor serial number (or any other short identifier string) be entered as a means of identifying the motor to the software. This is not obligatory, and both the networking software and MCM can function without this information.

Other communications settings:
All other communications settings should be left at the factory defaults if the MCM networking software is being used. If another software package is employed (i.e. SCADA software), please refer to its documentation for communication settings.

MCM can use both RS422 (4-wire) and RS485 (2-wire) standards. The RS422 standard can be used for up to 19200 Baud rates and the RS485 standard can be used for up to 9600 Baud rates. The recommended communication standard for MCM is RS422 (4-wire).

3.4 Running MCM

3.4.1 Introduction

Having configured MCM for a particular motor, it can now be used for its intended purpose of monitoring and assessing the condition of the motor. In general, this involves first running MCM to measure and learn the properties of the motor and then running MCM in its test mode to perform the actual monitoring.

NOTE
Without the learning period MCM has insufficient information on which to base its decisions as the motor ages and will not perform to its specifications.

For this reason, MCM ensures that a valid learning period is first performed before allowing the user to request the device to monitor the motor.

3.4.2 Alarm messages and status indication

3.4.2.1 Alarms specific to the motor

MCM divides warning messages into the categories of warnings, alarms and errors. Warnings inform the user that non-critical conditions have arisen that the user should be aware of but do not affect the performance of MCM. Alarms provide information specific to the motor being tested and are indications of faults caused

by incorrect connections to the motor, the supplied line voltage and/or motor currents being outside the specified limits and other conditions that prevent MCM from correctly determining the state of the motor. Alarms do not cause MCM to stop monitoring completely, but generally are indications that there is something that needs to be investigated and possibly changed before MCM can function to its full extent. In some cases an alarm may indicate a transient event such as high line voltages, which although damaging to the motor in the long term, do not indicate an immediate need for action. Of course if the frequency of such events is sufficiently high, the cause should be located and corrective action taken to remedy the problem.

NOTE
It is important to realize that when an alarm is displayed, MCM does not process the data taken from current and voltage channels. Therefore MCM cannot monitor the motor status.

It is therefore important to ascertain the cause of the alarm at the earliest opportunity.

3.4.2.2 Viewing alarm messages

An alarm is indicated on the front panel of MCM by the message Alarm followed by a hexadecimal value. The bits of the hexadecimal value refer to which alarm is raised. Repeatedly pressing the **RIGHT** or **LEFT** buttons cycles through a list of all active alarms. Please refer to the appendix for a complete list of possible alarm conditions and their remedies. The measured physical motor values can be viewed during an alarm by pressing the **UP** or **DOWN** buttons. This is often useful in determining the reason for an alarm.

3.4.2.3 Fault status indication

Status String	LED Number	Fault Severity
LEARN		**MCM has insufficient data to assess the status of equipment**
NORMAL	1	**Motor is healthy or level of failure is under alarm thresholds**
WATCH LINE	2	**There is a change on the supply voltage to the motor.** Temporary changes in supply voltage cause this alarm. If this alarm is persistent check: harmonic levels, capacitors, isolation of cables, motor connector or terminal slackness, loose contactors, etc.
WATCH LOAD	3	**There is a possibility of a load change:** If the process load has not been altered deliberately, check for leakage, valve & vane adjustment, pressure gauge faults, manometer, dirty filters (fans, compressors). If the process has been altered deliberately, MCM should be updated.
EXAMINE 1	4	**Plan Maintenance:** There are developing mechanical and/or electrical fault(s). Although the level of the failure is not serious, the maintenance should be done in the next planned outage, no later than 3 months
EXAMINE 2	5	**Do Maintenance:** There are developing mechanical and/or electrical fault(s). Maintenance and corrective action should be performed as soon as possible.

When monitoring a motor in test mode (**MONITOR**, **IMPROVE** or **UPDATE**), MCM provides a status indication on the right side of the upper display line. This consists of one of the items in the table above.

In addition, one of the five LED indicators on the front panel is lit showing the color corresponding to the motor status in the table above. As with all grading schemes, there is always some overlap between the bands and it is possible for a healthy motor sometimes to indicate a fault severity greater than 1. However, in healthy motor systems such false alarms should be transitory and prolonged display of a fault should indicate the need for maintenance.

NOTE
A prolonged fault indication should always be investigated.

3.4.3 Running CHECK MOTOR

On first use of MCM and each time any maintenance is performed on the motor, it is **essential** that the motor together with its connections are checked by running the CHECK MOTOR function. In this mode MCM performs a short check on all motor connections to determine the phase ordering and that a motor is connected and running. It also checks among other things, that the voltage and current levels are within set limits, and that the phase angle between the $\mathbf{V_1}$ and $\mathbf{I_{11}}$ - $\mathbf{I_{12}}$ channels is appropriate. If MCM detects that some condition is not met, an alarm is raised which the user should investigate and remedy before proceeding further.

3.4.3.1 Check mode command

The **CHECK MOTOR** mode is entered using the menu item:

MENU: Check Motor / Password

NOTE
If the **Local Lockout** setting is **ON** it is necessary to supply a password before access to the **CHECK MOTOR** mode is granted. The password is the same as used to access the Edit Settings menu.

Once **CHECK MOTOR** has finished, it will display either the message "Motor values" or a warning or alarm indication. At this point the **UP** and **DOWN** buttons can be used to cycle through a list of calculated physical parameters. If an alarm is present, pressing **LEFT** or **RIGHT** buttons will cycle through the list of alarms. Many of the alarm conditions relate to the calculated physical values and it is often useful to check the calculated values of the relevant parameters when trying to understand the origin of an alarm condition. Pressing **CLEAR** will return to the **IDLE** state.

The software utility MCM Configuration Toll found on the companion CD can be helpful when diagnosing problems during initial Edit Settings. The program should be installed on a portable PC and the PC connected (via a RS232 - RS485 converter)

to the communications port on the rear of the MCM device. Using the software it is possible to upload and display the voltage and current waveforms measured by MCM. Inspection of these waveforms can reveal problems caused by missing phases, phase ordering, phase imbalance, etc. Please refer to the MCMScada documentation and to the trouble shooting section of this manual for further details.

3.4.4 Setting and checking the input connections

When the **CHECK MOTOR** menu option is selected, MCM first determines the relative order of the voltage phases using the $\mathbf{V_1}$ channel as an arbitrary reference. It then attempts to place the current channel pairs in the correct order and polarity. The order determined by MCM can be displayed by entering the **EDIT SETTINGS** menu and selecting:

MENU: Edit Settings / Phase Ordering / Phase Order

On this menu, the voltages are denoted by the letters **R, S, T** and currents by **r, s, t**. A – sign preceding each letter indicates that the corresponding signal has an extra 180º of phase shift (i.e. that the polarity of the signal is reversed). Similarly, a + sign preceding a letter indicates that the polarity is correct. For example:

R-s+T+r+S-t

The above phase ordering display would indicate that relative to the first voltage (R) phase on input $\mathbf{V_1}$, the S and T phases (on $\mathbf{V_3}$ and $\mathbf{V_2}$ respectively) are reversed. The order of the current inputs is also incorrect with IS connected to $\mathbf{I_{11}}$ **-** $\mathbf{I_{12}}$, I_R connected to $\mathbf{I_{21}}$ **-** $\mathbf{I_{22}}$ and I_T connected to $\mathbf{I_{31}}$ **-** $\mathbf{I_{32}}$. Furthermore, the polarities of the two currents, I_S and I_T, have been reversed ($\mathbf{I_{11}}$ has been exchanged with $\mathbf{I_{12}}$ and $\mathbf{I_{31}}$ with $\mathbf{I_{32}}$**).**

NOTE
Once MCM has determined the correct phases, the user should not change the input connections without running CHECK MOTOR again.

The algorithm used by MCM to determine the phase order yields two solutions depending on the motor loading and extra information is required to obtain the correct sequence. To this end, MCM compares the measured RMS values for the currents with the nominal current entered by the user. If the ratio of the measured current to the nominal current is greater than the value of the **Load threshold** (expressed as a percentage), the motor is assumed to be working under loaded conditions and the appropriate solution is chosen. Otherwise the motor is assumed

not to be loaded. It is thus important to enter an accurate value for the nominal current. Even so, it is still possible for MCM to choose the wrong solution which will yield unrealistic values for the phase angle when the loading on the motor changes in use. MCM provides the possibility of overriding the detected phase sequence from the menu item **Order Override** under:

MENU: Edit Settings / Phase Ordering / Order Override

Changing the value of this item from OFF to ON allows the detected phase ordering to be altered by moving the cursor to the required position and scrolling UP/DOWN to select the desired value.

It is also possible to fine-tune the algorithm by altering the value of the **load threshold**. A higher value will tend to favor the unloaded solutions and *vice versa*. The load threshold can be found under:

MENU: Edit Settings / Alarm Thresholds / Load threshold

3.4.5 Running LEARN and IMPROVE

3.4.5.1 LEARN

MCM should learn the motor under normal operating conditions. The LEARN period consists of a preset number of data acquisition cycles and periods of data analysis. Once the preset number of cycles has been reached, the acquired and preprocessed data are further processed to produce a database consisting of a collection of data sets representing the behavior of the motor system under the load conditions that the motor has met in practice. It is therefore important to have the motor operating under its expected running conditions during a learning period. In order to adequately cover the range of load conditions experienced by a motor system, a sufficient number of acquisition cycles or iterations is required.

NOTE
We recommend that you use somewhere between 3000 to 4000 iterations as 4000 iterations typically provide adequate coverage under most load conditions.

Since additional learning can also be performed if needed during the testing phase, a larger number of learning iterations is not generally required. The number of learning iterations can be set from the menu path:

MENU: Edit Settings / Password / Run settings / Learn iterations.

3.4.5.2 IMPROVE

Selecting RUN from the main menu will initiate a new LEARN period. If data from a previous leaning period exist, the following message will be displayed:

"Lose learn Data? Clear to exit"

The user should press the **CLEAR** button if it is not desired to overwrite the existing data and **ENTER** if it is.

Once the initial learning period is complete, the MCM unit will automatically try to improve its estimation of the motor characteristics by updating the database obtained during the learning mode. The database is updated with different load and line conditions in the Improve mode. The duration of the Improve mode is determined by the number of Improve iterations set from the menu path.

MENU: Edit Settings/Password / Run settings / Improve Iterations

It is recommended that this value be set to between 8000 – 10000 iterations.

An important difference between this mode and the initial learning period is that MCM monitors the motor status during IMPROVE but does not during LEARN. Once the IMPROVE stage is complete, the MONITOR phase will automatically continue without user intervention. This is the main operating mode and MCM is expected to spend most of its time in this mode monitoring attached motor systems.

NOTE
In order to start monitoring, MCM must first have learnt the characteristics of the motor it is to monitor and have a valid learning mode.

3.4.5.3 Iteration cycle time

In general a data processing cycle takes between 60 – 120 seconds depending on several factors. First, MCM requires relatively unchanging data over a minimum time period during its data acquisition phase and will repeat the data acquisition until it obtains stable data, thus varying the iteration time cycle. If the amplitude or frequency of the voltage and current phases varies excessively and stable data

cannot be found, an alarm is raised. Secondly, if harmonic values are being calculated, extra processing cycles are required. Finally, if MCM encounters an error, it may repeat the cycle several times.

NOTE
If the *Local Lockout* setting is ON it is necessary to supply a password before access to any learning or monitoring mode is granted.

Once started, the monitoring process will continue until one or the other of the following conditions is fulfilled:

1. An error condition is generated and canceled.
2. The user presses the **CLEAR** button to cancel the process. In order to prevent unauthorized access, if the *Local Lockout* setting is set a password must first be entered.
3. Power to the MCM unit is cut.

3.4.5.4 Alarms during the monitoring process

Alarm conditions may occur during any monitoring phase. If CHECK MOTOR has previously been run on the motor, it is likely that the alarms represent transient conditions present on the power lines. However, it is suggested that any alarm representing a condition that could affect the performance of the motor should be recorded and investigated as a potential cause of motor degradation. As in CHECK MOTOR, if an alarm is indicated, the most recent physical values available for the motor can be displayed using the **UP** and **DOWN** buttons. Examination of these values can often indicate the precise reason for the alarm condition. A complete list of alarm conditions can be found in the appendix at the end of this manual.

3.4.5.5 Using an inverter drive

If an inverter is being used to drive the motor, several additional precautions are needed. The voltage frequency is expected to be constant (within well defined limits) for direct line driven motors, but can vary considerably when an inverter is used. MCM can handle the range of frequencies typical of an inverter, but first needs to learn the motor at a single frequency representative of the conditions it will meet in practice. The value of this dominant frequency must be entered from the Edit Settings menu. If MCM measures the frequency to be out of the expected

range, it will issue an alarm in both the CHECK MOTOR and LEARN modes and the user should adjust the frequency setting accordingly. During IMPROVE, UPDATE and MONITOR, this requirement is relaxed and the frequency can assume any value within the allowed frequency range.

NOTE

MCM is not suitable for the following applications:

- If motor supply voltage is changing over 15% in 6 seconds.
- If motor current is changing over 15% in 6 seconds.
- DC motors
- If motor is driven by an inverter whose chopping frequency is under 2 kHz.

3.4.6 Running RESUME and UPDATE

3.4.6.1 Canceling running

All the operating modes **LEARN**, **IMPROVE**, **MONITOR** and **UPDATE** can be stopped and started at any time without significant effect on monitoring performance, by pressing the **CLEAR** button (and providing the correct password if **Local Lockout** is ON). Subsequent restart of MCM can be achieved by selecting RESUME from the main menu, which will cause MCM to continue in its incomplete mode at the point of interruption. Thus, if it is necessary to stop MCM for any reason, it can be restarted without affecting any existing data.

3.4.6.2 UPDATE

At subsequent times it may be desirable to learn a new operating point of the motor. This can be done using the UPDATE function. This can be reached either

from the main menu in IDLE mode or by pressing first the **RIGHT** and then the **ENTER button** during MONITOR.

3.4.6.3 Updating the internal database

When MCM first starts in the **MONITOR**, **IMPROVE** or **UPDATE** modes, it has insufficient data to indicate the motor status accurately. Under such conditions a blank string may be displayed instead of the motor status. This is a temporary condition and should last only for the first data cycle. As a result of internal error handling, the blank string may occasionally be seen. Again, this is temporary and will pass by the start of the next data cycle.

Although MCM should have met the majority of working conditions in the learning mode, it is still possible for it to fail to recognize a particular working point. In such a case, the user can elect to add the current operating point to the internal database using the **UPDATE** feature. Running **UPDATE** will cause the internal database to be updated with the new information over a preset number of cycles. Once the count of iterations exceeds the preset number, MCM will automatically return to **MONITOR** without user intervention. The number of update cycles can be set from

MENU: Edit Settings / Password / Run settings / Update iterations

If it is necessary to learn the new operating conditions of the motor in order to add them to the existing database, **UPDATE** can be started in two ways. Firstly, in IDLE mode, the Update option should be selected and **ENTER** pressed**.** Secondly, from MONITOR, the **RIGHT** button should be pressed to display the message:

"Press **ENTER** for **UPDATE**"

Then **ENTER** pressed to select the mode.

As in the learning mode, sequentially pressing the **UP** or **DOWN** buttons allows the user to select and display the most recent values for the parameters calculated by MCM.

3.4.7 Advanced use

It is possible to customize the behavior of MCM by adjusting various settings. As usual a valid password must be supplied before the Edit Settings menu can be entered.

The following table summarizes the settings that can be changed together with their significance. It is recommended that the original values of each setting be recorded

prior to changing them. After changing certain settings it may be necessary to relearn the motor.

Menu Group	Setting	Usage
Harmonic Values	Harmonic Calc	Switch on/off calculation of harmonic values. Note that the calculation of harmonic values can significantly lengthen the cycle time.
	Signal Select	The channel number (1-6) of the channel to be used for harmonic calculations.
Calibration	Calibration	The calibration constants for the sensors on each channel.
Alarm Thresholds	Voltage balance %	Maximum permitted voltage imbalance
	Current balance %	Maximum permitted current imbalance
	Voltage range %	Maximum voltage range (as ± percentage range around nominal)
	Max Current %	Maximum permitted current upper limit (as percentage above nominal)
	Low voltage %	Minimum acceptable level below which voltage is considered to be zero for line and power fault alarms (as percentage of nominal)
	Low current %	Minimum acceptable level, below which current is considered to be zero for motor not running alarm (as percentage of nominal)
	Load threshold %	Used by the phase ordering algorithm to set the loading threshold. If the ratio of actual current to nominal current is more than the value of the Load threshold (in %) then the motor is considered to be working under load and the appropriate phase ordering selected. Otherwise, the motor is assumed to be unloaded.
Run Settings	Learn iterations	The number of data acquisition iterations required for a LEARN period. A value between 3000 – 4000 is recommended.
	Improve iterations	The number of data acquisition iterations required for the IMPROVE phase. A value between 8000 – 10000 is recommended.
	Update iterations	The number of data acquisition iterations required for an UPDATE phase. A value between 1000 - 2000 is recommended.

	Flash update rate	MCM does not update the flash with new values at each iteration, as this could shorten the flash lifetime. On the other hand, the longer data are stored in volatile memory, the greater the potential for data loss if power fails. As a compromise, the user can set a suitable time (measured in complete iterations) after which all outstanding data are automatically saved to flash.
	Local lockout	When this setting is on, passwords have to be supplied in order to start or quit a Check Motor or Monitor mode. Its purpose is to prevent any unauthorized tampering with MCM. Remote commands over the serial line are unaffected.
	Relay thresholds	Set the fault level for activating the output relay in MONITOR mode. If set, the relay is triggered by a change from a lower to a higher fault level any time the level is equal to or above the set level.
	Current stability %	When obtaining data, MCM requires relatively unchanging current signals. If the variation in the amplitude of the current exceeds this threshold, MCM will reject the data. The alarm UNSTABLE LINE is often seen when the current stability is set too low.

3.4.7.1 Monitoring motor and line parameters

In all operating modes (and after **CHECK MOTOR** has finished), it is possible for MCM to display selected parameters. Sequentially pressing the **UP** or **DOWN** buttons allows the user to select to display the most recent values for the parameters in the following table:

Displayed Parameter	Unit
Admittance	A/V
Phase angle	o
Power factor	-
Active power	W
Voltage balance	%
Current balance	%
V_1 RMS	V
V_2 RMS	V
V_3 RMS	V
I_1 RMS	A
I_2 RMS	A
I_3 RMS	A
Line frequency	Hz
Fit Parameter 1	-
Fit Parameter 2	-
Total Harmonic Distortion (THD)	%
3^{rd} – 13^{th} Odd harmonic levels	%

3.4.8 Equipment Faults and their diagnoses using MCM

MCM uses a model based fault detection and diagnostics technique. In this technique, the expected dynamic behavior (model) of the three-phase system under varying conditions, such as load, is determined and compared with the measured dynamic behavior to monitor abnormalities. MCM first learns the system for a period of time through acquiring and processing the real-time data from the system. The data is processed using system identification algorithms for the calculation of expected dynamic behavior and the model parameters. The changes in the parameters of the system indicate abnormalities developing in the system. Further, processing of these parameters is used for diagnosis.

As opposed to traditional vibration and current signature analysis, this approach uses a cause-effect (input-output) relationship and therefore is immune to the surrounding noise or noise in the inputs. Also the difference between expected and actual behavior filters out and enhances ONLY abnormalities generated by the system, which allows for earlier and more accurate warnings. The expert system approach eliminates the need for a database or record keeping, expert personnel, time-consuming data gathering and analysis. It provides comprehensive (mechanical and electrical as well as driven system) fault coverage though it measures only voltages and currents.

MCM uses the electric motor of the equipment as a sensor. Therefore, any fault of the equipment that affects the motor or the three-phase system is also observed by MCM.

MCM first learns the motor-based system for a period of time by acquiring and processing the motor data. The results of the processed data are stored in its internal database and a reference model is established. This reference model basically consists of model parameters, their mean values and their standard deviations. While monitoring, MCM processes the acquired motor data and compares the results to the data stored in its internal database. If the results obtained from the acquired data are significantly different from the reference model, MCM indicates a fault level.

The level is determined by taking into account the magnitude and the time duration of the difference. In total, MCM monitors and compares 22 different parameters (model parameters). These parameters are classified into three groups: electrical parameters, mechanical parameters and fit parameters. These are explained in detail in the following sections.

3.4.8.1 Electrical Parameters

There are 8 parameters in the first group that are called electrical parameters. These are the network equivalent parameters and are correlated to the physical parameter of the motor, like inductances, resistances, etc. They are sensitive to electrical faults developing in the motor. MCM evaluates and analyzes the differences between the model parameters at any instant and the average value of the same parameters that are obtained during the learn stage. These differences are normalized with respect to their standard deviations obtained during the learn stage. Hence the values indicate the number of standard deviations they are away from the average values obtained during the learn stage. If they exceed threshold values, then an alarm is given. The changes in their values are associated with the faults that are developing in the system. As an example, an isolation problem in winding will affect the parameters associated with resistances. Their change will allow MCM to detect the isolation problem at an early stage. Though they are primarily used to detect electrical problems, they also can indicate mechanical problems as well. As an example an imbalance or gear problem would cause dynamic eccentricity in the air gap. This eccentricity will cause a change in the induction parameters and therefore in the model parameters. By monitoring the changes in these model parameters, imbalance can be detected at an early stage. This eccentricity eventually affects the bearing eventually leading to its damage. Therefore, detection of eccentricity at an early stage can prevent further damages.

The electrical parameters are further classified in two groups, **E1 (internal)** and **E2 (external)** parameters. Electrical parameters 1-4 (**E1**) indicate problems associated with rotor, stator, winding etc. while 5-8 (**E2**) indicate electrical supply problems

such as voltage imbalance, isolation problem of cabling, capacitor, motor connector, terminal slackness, defective contactors, etc.

3.4.8.2 Mechanical Parameters

The parameters in the second group are sensitive to mechanical faults such as load imbalance, misalignment, coupling and bearing problems. They are called Mechanical Parameters 1-12. These parameters are obtained from the frequency spectrum of the electrical signals by extracting information from the line current and voltage supplied to a motor. The variances in the stator-rotor air gap are reflected back in the motor's current through the air gap flux affecting the counter electromotive force. Therefore, current carries information related to both mechanical and electrical faults. Hence, faults will exhibit a change in the frequency spectrum of the current evident in specific frequencies.

MCM uses the power spectral density (psd) obtained from the differences between the expected current obtained from the model and the actual current. These differences include only abnormalities generated by the motor. Therefore, they are immune to the noise or harmonics present in the supply voltages. The mechanical parameters indicate the power level of the difference between measured and estimated current at frequencies at which they occur in terms of number of standard deviations. If they exceed the threshold value, which is 8, an abnormality is indicated.

The mechanical parameters (M1-M12) correspond to the 12 maximum values obtained in the frequency spectrum. These parameters are also used for diagnosis. The frequencies at which they occur indicate the type of fault, i.e., an imbalance, loose foundation, oil whip, fan blades, inner or outer race of bearing, etc. These parameters are provided to the user for trending and diagnostic purposes.

3.4.9 Interpreting MCM fault indications

3.4.9.1 MCM status values

MCM employs two different measures for calculating the motor status: **Motor Status 1** and **Motor Status 2**. In addition to these, MCM also monitors load and line changes and summarizes the results of this monitoring via the **Load line status** parameter. **Motor Status 1** monitors the maxima of each of the three groups of parameters introduced in the previous section, over a window (with a default window size of 14 iterations in a monitoring mode) and compares them with four different internal thresholds calculated following the initial learning phase. **Motor Status 1** takes values between 1 and 5 is calculated as follows:

Condition	Motor Status 1	Meaning

All medians (over the window) of the maxima of the three groups of parameters are not above the first threshold	1	The motor is behaving as expected.
At least one of the medians (over the window) of the maxima of the three groups of parameters is above the first threshold	2	The behavior of the motor is slightly different than the reference model.
At least one of the medians (over one and a half times the window) of the maxima of the three groups of parameters is above the second threshold	3	There is a considerable difference in behavior between the reference model and the motor.
At least one of the medians (over two times the window) of the maxima of the three groups of parameters is above the third threshold and the median (over the window or one and a half times the window) of the maximum of another group of parameters exceeds the first or the second threshold.	4	There is a significant difference in behavior between the reference model and the motor.
At least one of the medians (over two and a half times the window) of the maxima of the three group of parameters is above the fourth threshold and the median (over the window or one and a half times the window or two times the window) of the maxima of the group of parameters exceeds the first or the second or the third threshold.	5	The motor is behaving in a manner totally different from the reference model.

Motor Status 2 also takes values between 1 and 5. The calculation of **Motor Status 2** is based on counting the frequency of the values of **Motor Status 1**, that are greater than one, and the frequencies of any load and line changes over larger windows. Window sizes and frequency thresholds used for the calculation of **Motor Status 2** are selected so that a temporary change in Motor Status 1 does not cause any change in **Motor Status 2**. The meaning of each level is summarized in the following table.

Condition	Motor Status 2	Meaning	MCM Display
The frequency of **Motor Status 1** values greater than 1 does not exceed the first frequency threshold.	1	Motor is running normally	OK
The frequencies of **Motor Status 1** values greater than one and the line changes exceed the specified thresholds	2	The motor is behaving in a manner differing from the reference model. This difference may be due to power line voltage levels not encountered during the learning phase.	Line
The frequencies of both **Motor Status 1** values greater than 1 and load changes exceed the specified thresholds	3	The motor is behaving in a manner differing from the reference model. This difference may be due to loading conditions not encountered during the learning phase.	Load
The frequencies of **Motor Status 1** values greater than 1 exceed the second frequency threshold and the frequencies of both line and load changes are below their corresponding thresholds.	4	The motor is behaving in a manner differing significantly from the learned reference model, due to a fault developing in the motor and/or the systems connected to the motor.	Examine1
The frequencies of **Motor Status 1** values greater than 1 exceed the third frequency threshold and the frequencies of both line and load changes are below their corresponding thresholds.	5	The motor is behaving in a manner bearing no relation to the learned reference model, due to a developing fault in the motor and/or in the systems connected to the motor.	Examine2

The **Load line status** parameter of MCM takes values between 0 and 15. Its possible values correspond to combinations of the bits of a binary number, with each bit having the significance given in the following table:

Bit	Value	Condition
0	1	Voltage values are outside the range encountered during the learning phase.
1	2	The vector sum of the three phase voltages (voltage balance) is out of the range encountered during the learning phase.
2	4	Fluctuations in the three phase voltages have changed in comparison with the fluctuations encountered previously over a moving window.
3	8	Loading conditions are different from the loading conditions encountered during the learning phase.

Thus a **Load line status** value of 9 would result from the arithmetic sum of 8 and 1, and would correspond to conditions 0 and 3 holding and conditions 1 and 2 being false. This would mean that both the voltage values and the loading conditions differ from the conditions met during the learning period but that the voltage balance and voltage fluctuations were consistent.

The motor status values displayed on the front panel of the MCM unit and reported by the MCMScada monitoring software are actually the values of the **Motor Status 2** parameter. **Motor Status 1** is not available from the front panel and can only be monitored using the trending plots of MCMScada. The LED indicators on the front panel of MCM correspond to the values of **Motor Status 2**, starting with OK (value of 1) on the left and increasing up to **Examine 2** (value of 5) on the right.

3.4.9.2 Changes in line voltages

Motor status alarms associated with the changes in the line conditions are indicated by the "**Watch Line**" message on the front panel, the second (yellow) LED indicator being lit and **Motor Status 2** having the value of 2. They are usually temporary in nature and generally the user does not need to take any action. However, it is recommended that when this status level occurs, the user should at least assess the extent of the change in the line conditions, as significant changes in the line voltages and currents may be dangerous to the motor. If the line status change is persistent, the user should assess the root cause of this change. For instance, it may be due to a problem in the contactors or for inverter driven motors the settings of the inverter may have been changed. In any case, if the root cause cannot be remedied easily and quickly and the new voltage supply condition presents no danger to the motor, the user has the option to send MCM to the **UPDATE** mode. This will allow MCM to learn the new voltage supply conditions, after which the status will eventually return to normal.

3.4.9.3 Load changes

Motor status levels associated with changes in the loading conditions occur with the "**Watch Load**" Message on the front panel, the third (orange) LED indicator being lit, and **Motor Status 2** taking a value of 3. They are also temporary in nature but they should be treated more carefully than line changes, as some faults developing in motor-based systems can cause changes in the loading conditions. For instance, leakages from pump seals can cause pressure drops, which will be interpreted by MCM as changes in the loading conditions. Similarly, clogging in a pipe or membrane or an increase in the friction of moving parts will be detected as changes in the apparent load.

It is, therefore, important to assess the root cause of the load change. In certain cases, (for instance, closing or opening a valve or changing a pipe), the changes in the loading conditions are intentional and should already be known by the user. In such cases, the user should send MCM to the **UPDATE** mode so that it will learn the new loading conditions. When no obvious cause can be found, it is likely that a fault is indeed developing and the situation should be monitored more carefully.

3.4.9.4 Error messages

Unlike alarms, errors refer to **failures of the MCM hardware and software** rather than the monitored motor. When MCM discovers an error condition it makes several attempts to recover, and only if these attempts are unsuccessful is an error message generated. All errors stop MCM from functioning and must be cleared before proceeding further. Errors are indicative of a serious problem within MCM and their source should always be investigated. An error indication consists of two parts: Firstly the displayed error string; and secondly the associated error number. When reporting device malfunctions, please be sure to include both the message and its associated number. Please refer to the appendix for a full list of error messages.

Viewing error messages and numbers

MCM indicates an error to the user by the string Error on the first line of the display followed by the error string on the lower line. Pressing the **RIGHT** or **LEFT** buttons will display the error number.

Canceling errors and performing a master reset

NOTE
Performing a hardware reset in this manner resets all settings to the factory defaults and all previously saved information will be lost. This includes all learning mode and Edit Settings data, so a hardware reset should be used only as a last resort.

Pressing the **CLEAR** button will cancel the error and return to **IDLE** in most cases. If the error occurs during an error recovery operation it will not be possible to cancel the error in this manner but will require a full master reset. This is accomplished by holding down the **LEFT** button, while simultaneously either switching on the device power or pressing and releasing the reset button at the rear of the device.

NOTE
The unit must be in the IDLE state before removing the power or pressing the reset button or this procedure will not work.

The button must remain held down for at least four seconds until the message appears on the display:

"Press Enter for general reset"

At this point **ENTER** should be pressed to perform the reset. If this does not clear the error, it is likely that the MCM device is experiencing a hardware fault and that the unit should be returned for servicing.

3.4.9.5 Using the relay output

MCM is equipped with two connections on the rear panel internally connected to a low power, normally open relay. Closure conditions of the relay can be programmed from

MENU: Edit Settings / Password / Run settings / Relay Threshold

Select the desired fault level. During MONITOR, IMPROVE and UPDATE, the relay will become active anytime the fault level rises above the selected relay level, and the following message will be displayed:

"Relay active"

When the relay is active and the previous message displayed, pressing the **LEFT** or **RIGHT** buttons cycles through the messages:

"Acknowledge"
"Reset relay"

Pressing the **CLEAR** button while either of these messages is displayed deactivates the relay. Selecting ''Acknowledge'' will cause the relay to activate again only when

the motor status exceeds the current value. ''Reset relay'' will allow the relay to activate again when the same preset conditions are next met, possibly as soon as the next data cycle.

Relay output absolute maximum ratings	
Current (A)	**Voltage (V)**
2.0	30 (DC)

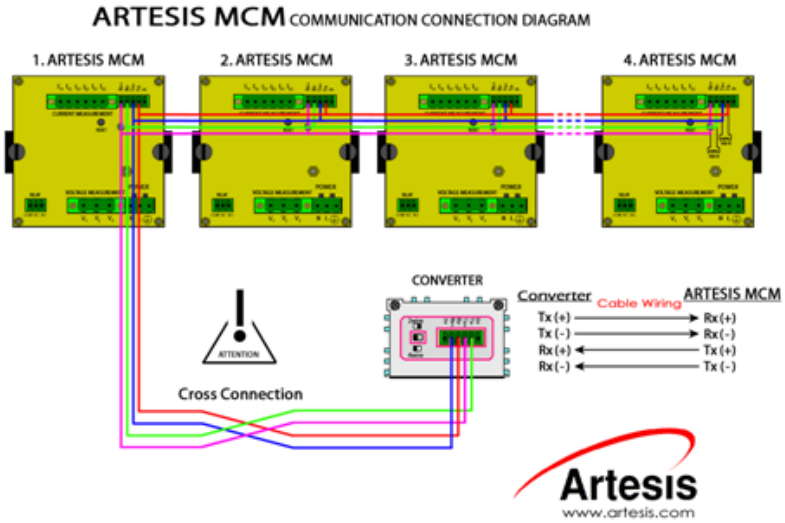
Relay Output States				
	Relay Contacts			
State	**NO**	**COM**	**NC**	**COM**
Relay active	Closed		Open	
Relay inactive	Open		Closed	

3.4.9.6 Connecting to the serial port

MCM can be connected to a PLC or other monitoring system such as MCMScada via the RS485 port on the rear of the device. Artesis makes available its proprietary protocol on request in document entitled MCM System Communications Protocol Document for End Users. Please contact Artesis to obtain this document.

RS 422 port connections			
Pin	**Description**		**Notes**
1	Receive A	Rx+	For 2-wire connect to Tx+
2	Receive B	Rx-	For 2-wire connect to Tx-
3	Transmit A	Tx+	
4	Transmit B	Tx-	
5	Common	0	Optional connection to local ground via 100 Ω resistor

Connecting devices to a RS422 4-wire network



MCM uses 2-wire or 4-wire RS422/RS485 communications with optically isolated (to 2500V) inputs and outputs. MCM is configured as a slave device and needs to be addressed before it will communicate over the bus. It will support communication rates of up to 19,200 Baud over distances exceeding 1000m, but this rate can be degraded if the environment is especially noisy. For 2-wire connections, each terminal pair Tx+ / Rx+ and Rx- / Tx-must be connected together on each MCM device. In some cases, particularly with slow PC hosts that do not release the transmit line rapidly; it may be necessary for the MCM device to delay its response. This can be achieved by adjusting the value of the menu setting:

MENU: Edit Settings / Comm. Settings / Response Delay

In the diagrams given above, the terminals marked 0 on each MCM device are connected together and with the 0 terminal on the converter. Internally, these terminals are connected to the local ground via 100 Ω resistors. This optional connection is provided in order to have a quality return path for the differential signals, which can in some circumstances reduce noise and lead to better communications. In cases where the ground quality is adequate, this connection can be left unused. Similarly, terminating resistors between the terminals on the last device in the daisy chain (star topologies are not recommended) may be used. These resistors (typically of value 120 Ω, depending on the impedance of the cable used) may not be needed in short networks with few devices, but at higher baud rates and as the network length increases, their inclusion becomes essential.

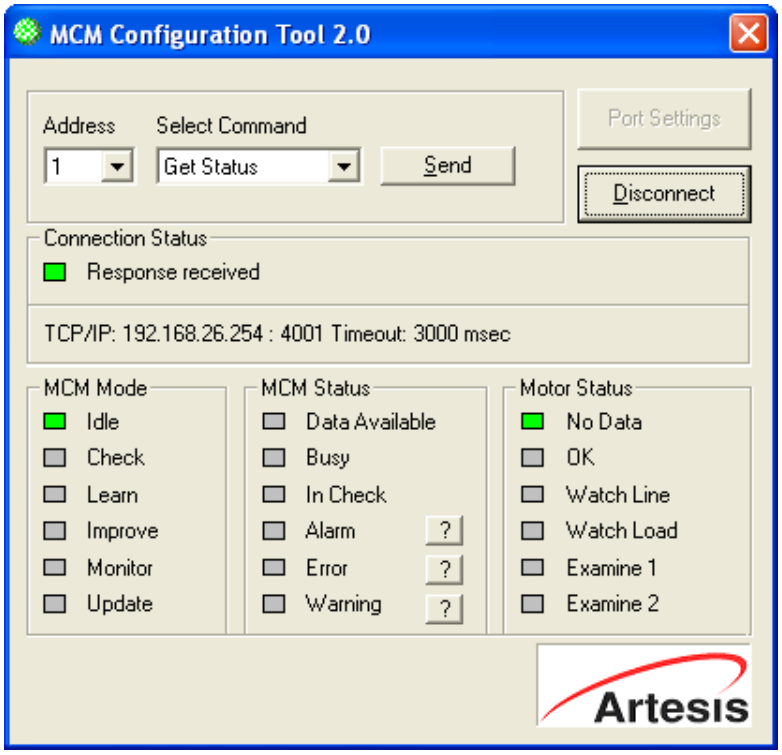
4. Troubleshooting

4.1 Introduction

During installation and operation a number of checks should be made to ascertain whether the MCM unit is performing correctly and to determine possible causes if it is not.

4.2 Use of the MCM Config utility

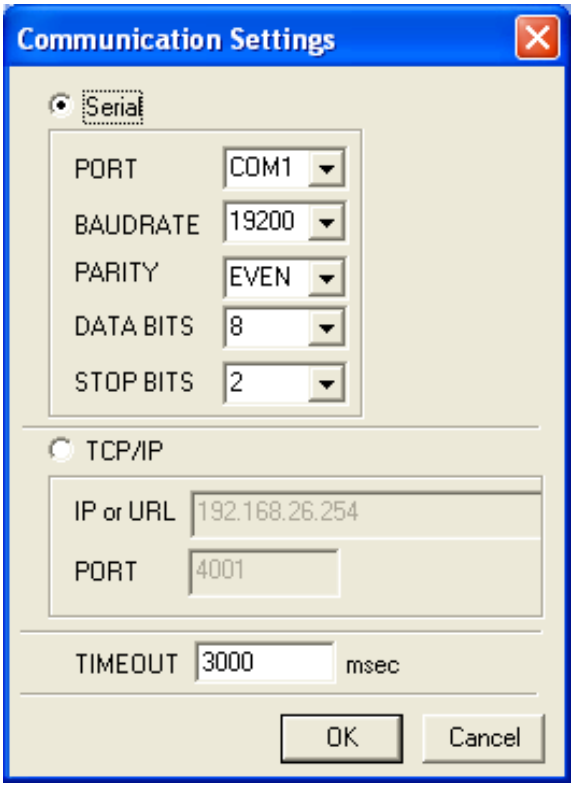
The MCM Config software is a simple test utility provided by Artesis for examination of waveforms, and can connect to a single MCM unit using the RS485 serial line on the rear of the instrument. If a network is available, MCM Config can be installed on the host computer, otherwise a portable laptop machine equipped with a suitable RS232/485 converter should be made available for this purpose.



4.2.1 MCM Config View

When connecting to an MCM unit, the following steps should be observed:

Select the pc communications settings by pressing the **Port Settings** button at the top of the view. This will bring up the Communications Settings window shown below.



There are two types of connection options that are available. If your PC is directly connected to the RS485/RS232 serial converter via a serial port, then make sure that **Serial** is selected, and enter serial communication settings in the relevant boxes below. The default settings are:

- Port: COM1 (This depends on your PC's setup, but most PC's have only one serial port which is addressable at COM1 by default)
- Baud rate: 19200
- Parity: EVEN
- Data Bits: 8
- Stop Bits: 2

If you are going to connect to a remote MCM or MCM network using a TCP/IP connection, then make sure that **TCP/IP** is selected, and enter the TCP/IP connection settings in the relevant boxes below. These will depend on your network configuration.

When you hit Connect button, Configuration utility will automatically try to connect to the default address of 1, and display the status of the connection inside the Connection Status box. If the MCM has a different address, select the appropriate address from the Address selection box. Configuration utility should connect to the device and display its status as green or red boxes inside the MCM Mode, MCM Status and Motor Status boxes.
You can send commands to the MCM by clicking on the Select Command box, which brings up a list of available commands. Choose commands from the list below to test various functions of the MCM.

Command	Explanation
Get Status	Updates the status information
Go Idle	Sends MCM to the IDLE state
Check	Sends MCM to the CHECK state
Update	Sends MCM to the UPDATE state
Resume	Sends MCM to the RESUME state
Run	Sends MCM to the MONITOR state
Get Alarm	Gets alarm information from the device
Get Error	Gets error information from the device
Get Warning	Gets warning information from the device
Get Version	Gets MCM's version
Take Data	Starts acquisition of VI data for later viewing. This also enables upload status elements
Get RMS	Gets RMS values from the device
Get Settings	Gets MCM settings and displays all the setting values for checking & editing
Download PSD data	Gets PSD values from the device
Download VI data	Downloads previously recorded VI data for viewing. Use of Take Data is recommended for latest VI values.

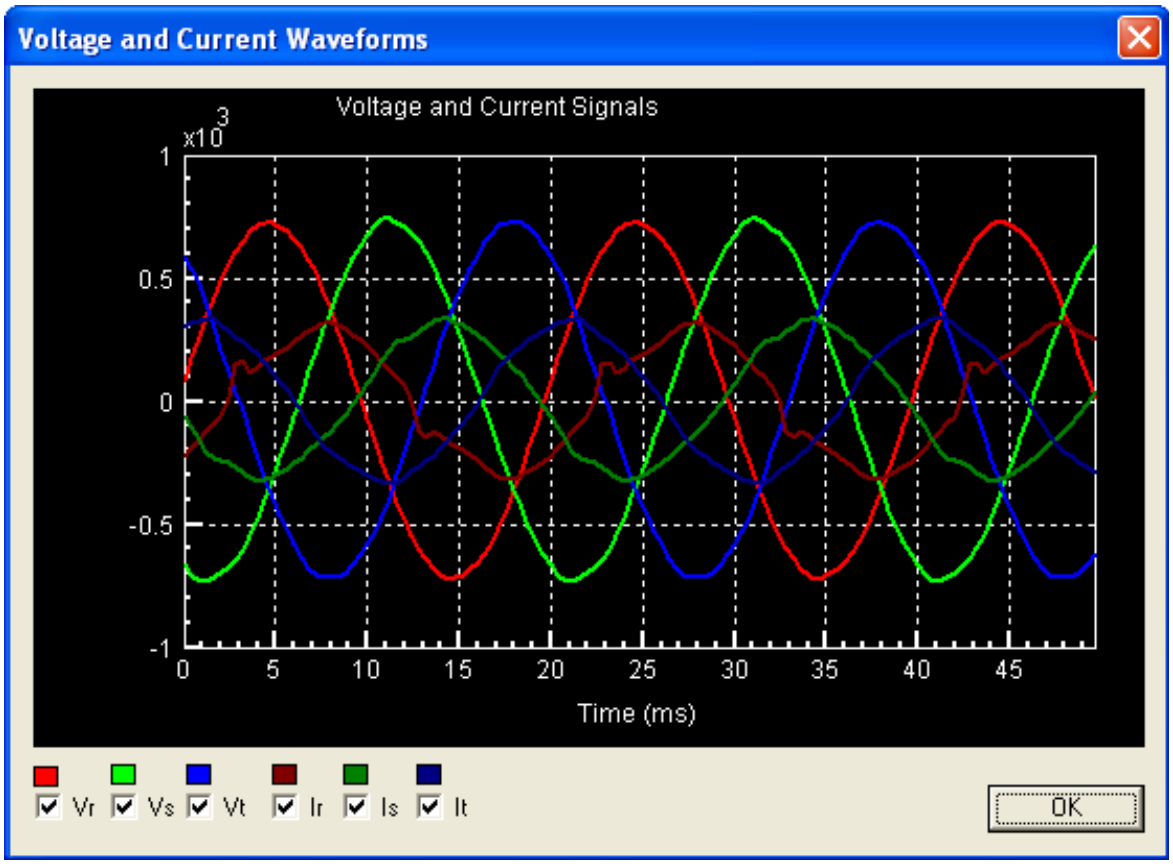
Check system response by sending a Get Status message. This is done by selecting **Get Status** from the Command selection combo box and pressing the **Send Command** button. If "Response Received" message does not appear in the Connection Status box in the amount of time specified earlier as the timeout interval, check the connections, cabling, baud rate, pc ports, etc.
Waveforms of the last data acquired by MCM during data acquisition can be uploaded to the pc for inspection as follows:

Send the MCM unit to IDLE mode by selecting the **Idle** command from the Command Selection combo. Note that the unit always sends the current data stored in its memory so after any changes to the input conditions it will be necessary to refresh the stored data by sending the unit to CHECK MOTOR mode using the **Check Motor** command.

Initiate the upload mode by sending the **Take Data** command. The software will wait 6 seconds and then enable the Upload button. Press the Upload button and observe the "Data Received: " text displayed together with the current number of data points. The progress bar in the Upload Panel will indicate how much data has been downloaded. When sufficient data available, press the **Cancel Upload** button to display the voltage and current waveforms. The view can be zoomed using the mouse to define the desired region while holding down the left button. Pressing the right button restores the view.

Voltage and current waveforms corresponding to the same phase are plotted in the same color. If the **Display calibrated data** checkbox is selected, the data are scaled according to the device calibration. Deselecting this box is sometimes useful to view both the voltage and current waveforms together. The following waveforms are scaled.

You can turn off any of the waveforms you do not wish to see by disabling the appropriate checkbox next to the label indicating this waveform.



4.3 Fault Diagnosis

A number of common problems can be diagnosed by inspection of the measured waveforms, and it is good practice to check the waveforms of each unit as part of the commissioning process. With the motor running, and power applied to MCM:

Voltage phases should have the correct RST phase relationships, separated by 120º. The current phases should be in the same order as the voltage phases and also separated by 120º. Any phase ordering, missing or duplicate phase problems should immediately be seen from the waveform display.
For star connected motors, it is essential that the phase angles between corresponding voltages and currents lie between 0 and 90º. Motors connected using the delta topology have an extra 30º phase shift and the current phase angles should lie between –30 and +60º. In either case, check that the motor topology has correctly been entered on the MCM front panel and that the currents do indeed correspond to the correct voltages. It is important to perform this test with the motor under loaded conditions as loading can significantly affect the measured phase angle.

For delta connections check that the sensors are measuring the line rather than phase currents, (i.e. the sensor is situated on the line side of the contactor) as these differ. For star connections the two are the picture same.

If the amplitude of the R phase current waveform varies excessively, MCM will not be able to find stable data and will give the unstable line alarm. If the problem lies with the input signals, it should be immediately obvious by inspecting the displayed waveform. In the case of excessive variation of the R phase current amplitude, the Current Instability threshold should be incremented from its default value of 15% in steps of 5% up to a maximum value of 50% using the MCM front panel. If the variation exceeds this level, please contact Artesis.

NOTE
All phases should be checked for correct, clean, zero crossing.

If a waveform appears to be regular and sinusoidal over consecutive half periods, but does not cross through zero, it is likely that the zero crossing detection hardware is defective and the unit should be replaced. If however, the waveform is irregular the problem could lie with the sensors. In this case check all cabling and power supply connections. If these are satisfactory, return the unit if the problem lies with

a voltage channel. For current channels, try replacing or swapping the sensor with another one. If the new sensor does not work the problem is internal to the MCM unit and it should be returned to Artesis.

If any phase has a marked difference in amplitude to other similar phases, the calibration constant for that phase should be checked. If no external sensor is attached (i.e. for low voltage motors) the calibration constant should be 1. If the calibration is correct, the sensor may be defective and should be changed.

Check the current balance levels using the MCM front panel. A value below 15% is acceptable, but above 15%, the Total Harmonic Distortion (THD) on all current phases should be checked. Normal levels for THD can be up to 6% depending on conditions.

For values higher than this level check whether the distortion originates from the motor or the line, by measuring the THD present at other motors connected to the same supply. If the same level for THD is measured at other motors, the line supply is suspect and should be investigated as high levels can damage motors in the long term.

Otherwise, the motor is probably already damaged in some way and should be investigated.

Check the voltage imbalance levels using the front panel. A value below 5% is deemed satisfactory. Above this level, check the THD levels on each voltage phase. Levels above 5% should be investigated. The ability of MCM to detect faults will be reduced as voltage imbalance increases.

Check that all waveforms disappear when power is removed from the motor.

4.4 Servicing

MCM contains no user serviceable parts and must be returned to either Artesis or its designated agents if repair is needed.

4.5 Cleaning

Clean the display and the keypad periodically using a dry cloth. Detergents can damage the device. Do not use detergents.

5. Appendices

5.1 Appendix 1: MCM Error, alarm and warning conditions

5.1.1 Error Conditions

Format	First Byte	Minor code
	Second Byte	Error type

Error Number	Error type	Description
0x010000	Memory allocation error	The dynamic memory manager failed in a request to allocate a block of memory
0x020000	General error	An unexpected or general error occurred
0x040000	Zero division	The algorithm attempted to perform a division by zero
0x080000	Flash Write	There was an error attempting to write to flash
0x100000	Illegal square root	The algorithm attempted to form the square root of a negative number
0x200000	Initialization error	Initialization was not properly finished, or an error occurred
0x400000	No data error	There is no data present
0x800000	Data acquisition error	An error occurred during data acquisition causing insufficient data to be acquired
0x01000000	Parameter error	An illegal value was calculated for an algorithm parameter
0x02000000	Flash error	An attempt to read or write from the flash RAM gave an error indicating a faulty flash. The device can only be restarted by removing power and performing a general reset
0x04000000	Cluster error	An illegal cluster value was detected.
0x08000000	Flash data error	Data stored in the flash RAM is corrupted and cannot be used. This error is generated during both learn and test modes following an attempt by the algorithm to recover from another fault
0x10000000	Stability error	Clusters used by the algorithm are inherently unstable
0x20000000	Voltage range error	An illegal voltage value was detected

5.1.2 Alarm Conditions

Alarm Number	Alarm type	Description
0x0001	Voltage balance	Voltage phase imbalance exceeds the set threshold
0x0002	Current balance	Current phase imbalance exceeds the set threshold
0x0004	Voltage range Ch1	Voltage greater than the upper threshold
0x0008	Voltage range Ch2	Voltage greater than the upper threshold
0x0010	Voltage range Ch3	Voltage greater than the upper threshold
0x0020	No voltage Ch1	Voltage less than acceptable (No voltage) limit
0x0040	No voltage Ch2	Voltage less than acceptable (No voltage) limit
0x0080	No voltage Ch3	Voltage less than acceptable (No voltage) limit
0x0100	High current Ch1	Current exceeds upper threshold limit
0x0200	High current Ch2	Current exceeds upper threshold limit
0x0400	High current Ch3	Current exceeds upper threshold limit
0x0800	Motor not running	All currents were measured below their acceptable (No current) limits
0x1000	Motor connection fault	One or more currents were measured below their acceptable limits
0x2000	Line fault	One or two voltage phases were compatible with zero (below No voltage limit)
0x4000	Power fault	All the voltage phases were compatible with zero (below No voltage limit)
0x8000	Unstable line	The power lines were not sufficiently stable to allow the algorithm to obtain data (amplitude and frequency variations of current and voltage were excessive)
0x10000	General fault	General fault consisting of one or more of: No data obtained, no zero crossings detected, perfect phase balance (voltage or current)
0x20000	Phase ordering	The phase ordering used by MCM is incorrect and must be rectified.
0x40000	Phase fault	Voltage phase angles incompatible with 120º were detected
0x80000	Phase angle	The measured phase angle between corresponding voltage and current channels was not in the range: $0 <= \varphi <= \pi/2$
0x100000	Current phase fault	The ordering of the current phases was different

Alarm Number	Alarm type	Description
		to that of the voltage phases or the angle between two phases was not 120º
0x200000	Data acquisition fault	Division by zero was attempted during data acquisition
0x400000	Range error	An illegal value was detected for one or more of the following quantities during data acquisition: Calibration constants, balance values, admittance, estimated physical parameters
0x800000	Frequency range	(**CHECK MOTOR** and **LEARN** only). The measured frequency differed from the nominal value. During the learning period, MCM learns the motor only at the dominant frequency. In inverter driven systems, it is important to set the nominal frequency to this dominant frequency otherwise, MCM may never complete the learning period. This condition is relaxed during normal monitoring (**IMPROVE** and **UPDATE**) where unlearned frequencies are updated automatically
0x1000000	Frequency tolerance	Illegal value for the mean frequency (**IMPROVE**, **UPDATE** and **MONITOR**)
0x2000000	Noisy data	The estimated admittance is inconsistent with the measured RMS values for voltage and current. This usually indicates excessive noise in the data

5.1.3 Warning Conditions

Warning Number	Warning Type	Description
0x01	Test frequency range	(**MONITOR**, **IMPROVE**, **UPDATE** only) The measured frequency was different than (i.e. outside the threshold of) the **LEARN** frequency
0x02	Residual error	An unexpectedly large value was calculated for the modeling error. This is generally an indication of an unstable line condition and will usually pass
0x04	Data size reset	Values for some quantities were checked and found to be outside their allowable limits. The values were reset to the upper or lower limits
0x08	Phase ordering	Phase ordering is different from the values set
0x10	Unstable system	Instability was detected for the system

5.2 Appendix 2: Current and voltage sensor selection

Voltage transformers, current transformer and current sensors must meet local standards and regulations. For North America, current and voltage transformers must be certified by an OSHA appointed NRTL to appropriate UL or CSA - product safety standards.

When selecting a current sensor, both the maximum current the motor will handle in practice and the type of motor drive used should be considered. Systems employing an inverter will generally limit initial inrush to a maximum of about 150% of nominal current.

With a soft-starter system this limit will probably be 400%. Sensors must be able to withstand the maximum expected inrush currents and should be selected accordingly.

Sensors should be selected such that the nominal motor values for current and voltage are around 70% of the corresponding sensor rating. Alternatively, for current transformers, the secondary current at nominal motor current should be between 3.5 – 4.5A and the same for voltage transformers. Failure to do so will result in a loss of sensitivity and the ability of MCM to detect motor degradation or change.

5.2.1 Inverter driven systems

Sensors used for measuring currents should be selected depending on the power of the motor to be monitored by the MCM device. The three current sensors are connected in series with each of the three the motor power cables. Power to the current sensors is provided by separate power sources fitted inside the motor control panel.

Hall-effect current sensors must be used with MCM Inverter units. The secondary of the current sensor must be SELV (Safety Extra Low Voltage).
Voltage transformers should be 1% accurate or better with 100V, 110V, or 120V secondary voltage.

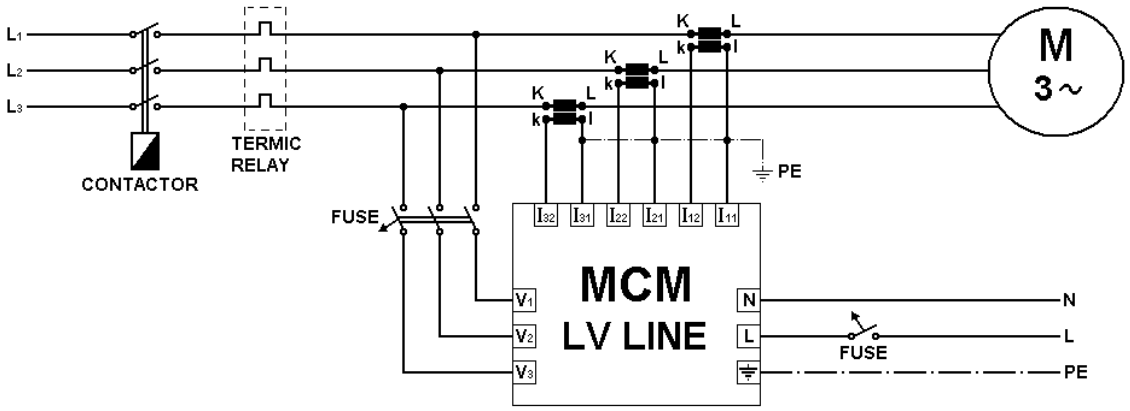
5.2.2 Line driven systems

Current transformers should be 1% accurate or better. The secondary current should be either 5A for 5A MCM units or should be 1A for 1A MCM units. The secondary of the current transformer has to be SELV.

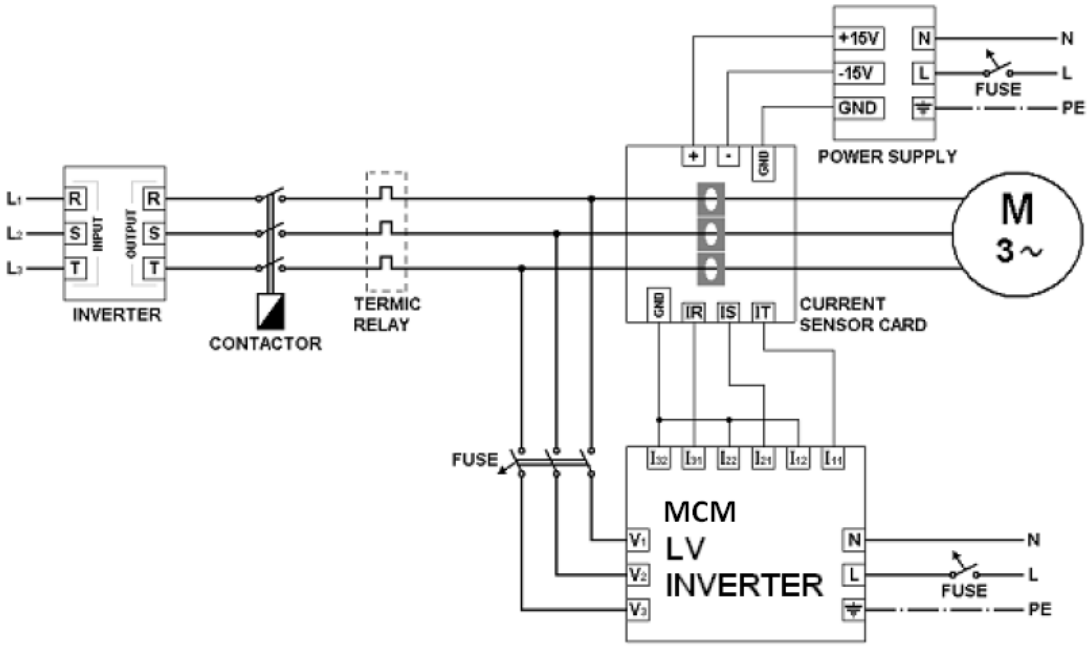
Voltage transformers should be 1% accurate or better with 100V, 110V, or 120V secondary voltage.

5.3 Appendix 3: Connection Diagrams

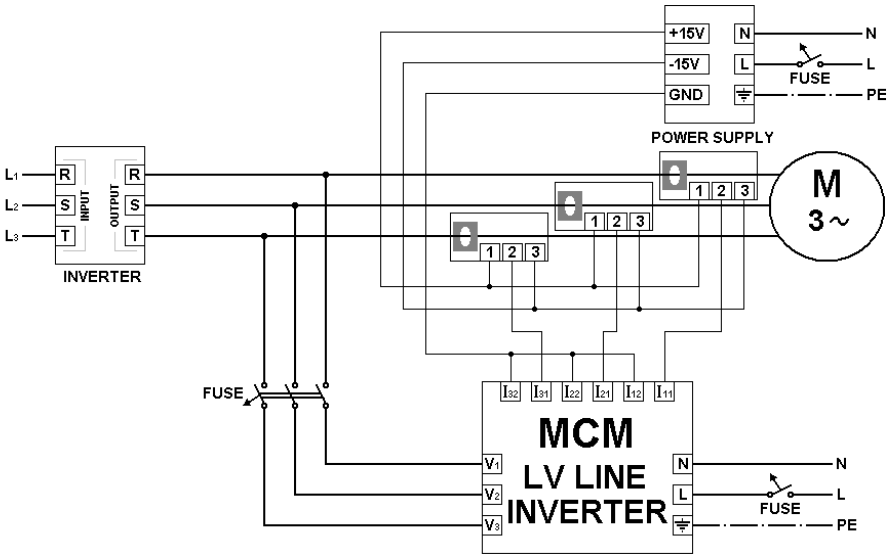
5.3.1 Low voltage line driven motors with current transformers (MCM LV Line)



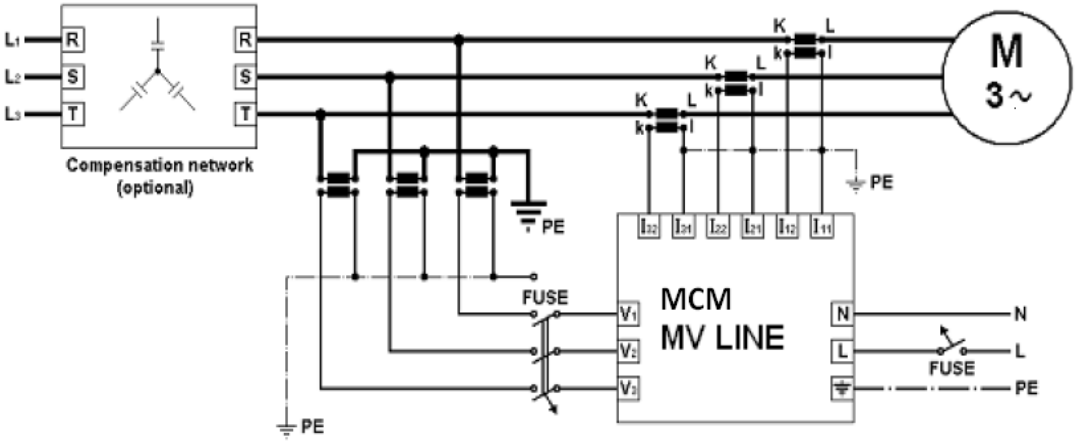
5.3.2 Low current (5 - 200A), low voltage, inverter driven motors (Hall Effect Sensor & MCM LV Inverter)



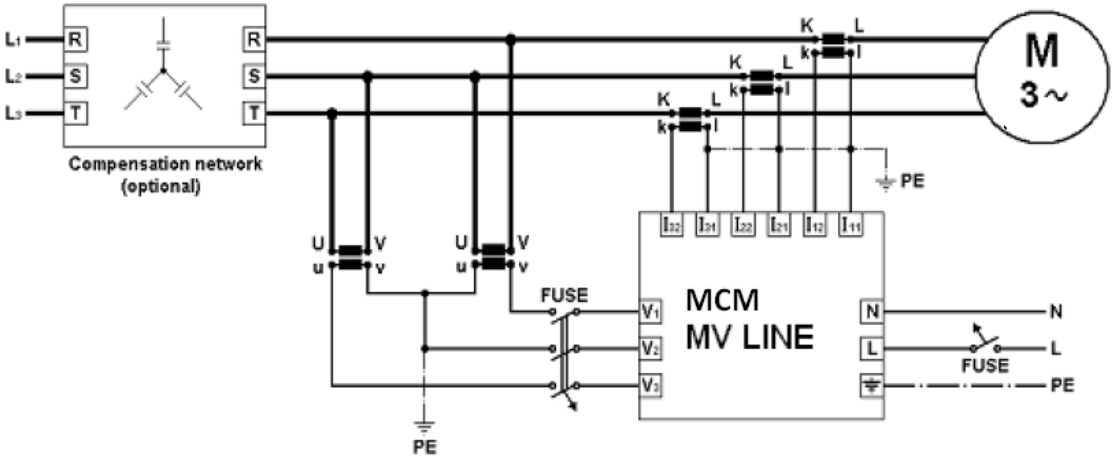
5.3.3 High current, low voltage, inverter driven motors with current range of 201-2000A (Hall Effect Sensor & MCM LV Inverter)



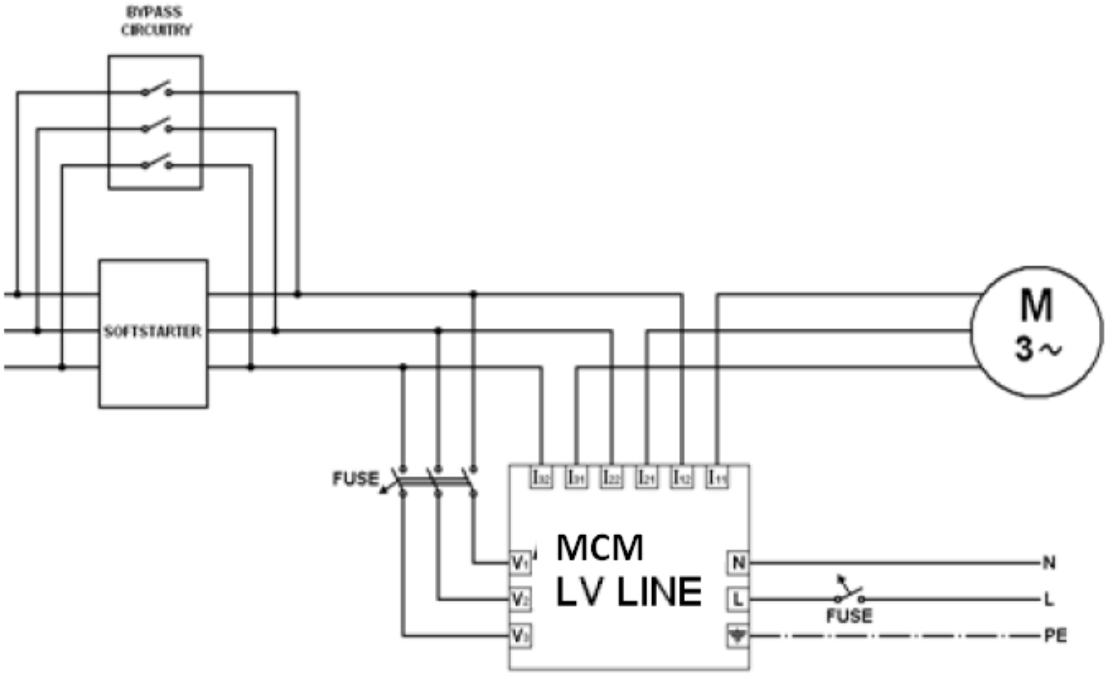
5.3.4 Medium/high voltage motors with voltage & current transformers (MCM MV Line)



5.3.5 Medium/high voltage, Aron connected motors (MCM MV Line)

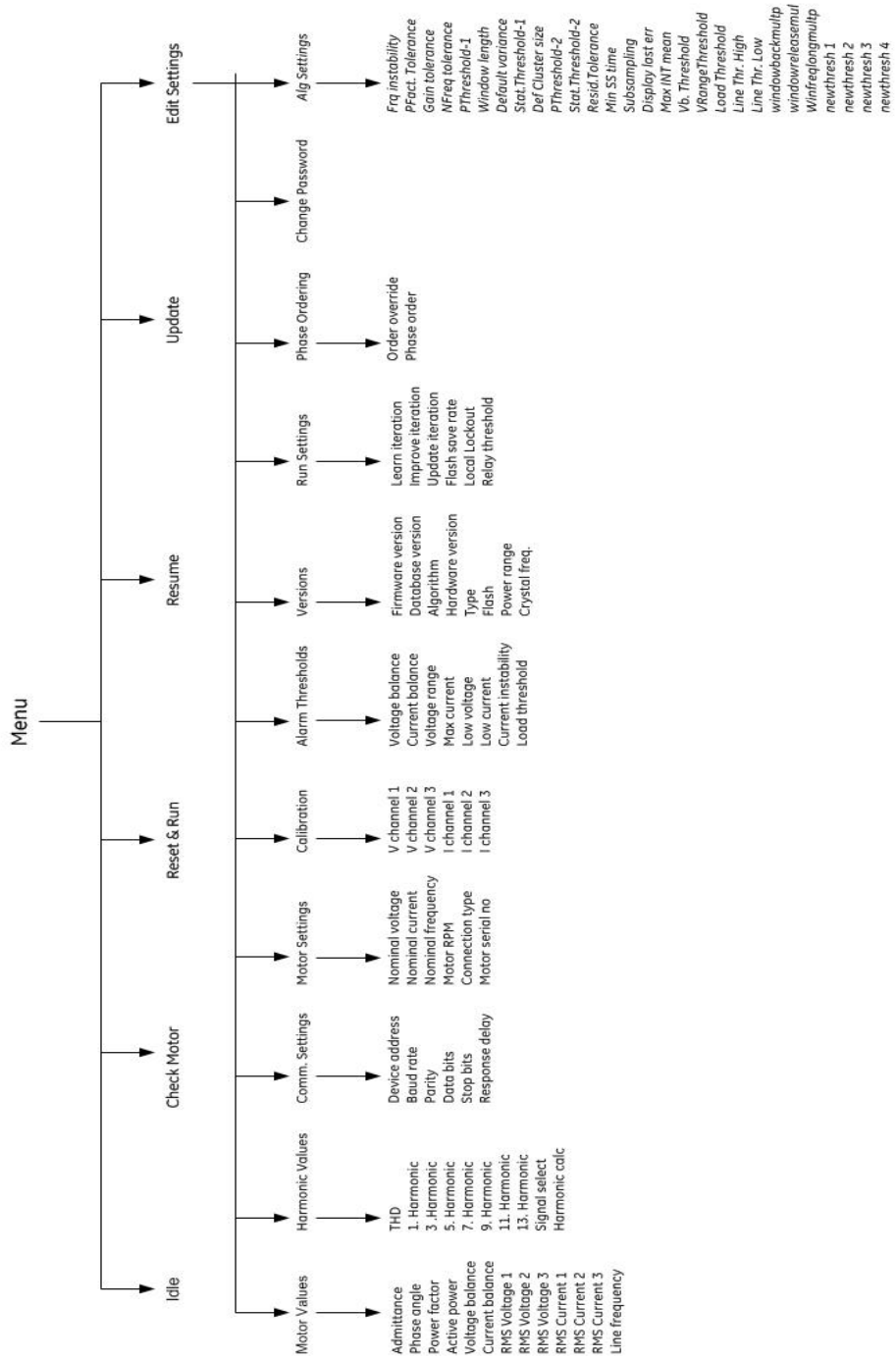


5.3.6 SoftStarter



5.4 Appendix 4: Menu settings and parameters

MCM menu is password protected and the default password for the menu is "m". The default password can be changed from the MCM menu.



5.5 Appendix 5: Edit Settings Menu items

Edit Settings Menu Group	Submenu items	Description	Type	Range	Default Value
Motor Values	Admittance	Ratio of RMS current to voltage	Display only	N/A	N/A
	Phase angle	Angle between V_1 and I_1 channels in degrees (φ)	Display only	N/A	N/A
	Power factor	Cosine of phase angle between V_1 and I_1 channels (Cos φ)	Display only	N/A	N/A
	Active power	V*I* Cos φ	Display only	N/A	N/A
	Voltage balance %	Calculated based on NEMA (National Electrical Manufacturers Association) definition. A measure of imbalance between phases (0 = perfect balance)	Display only	N/A	N/A
	Current balance %	Calculated based on NEMA (National Electrical Manufacturers Association) definition. A measure of imbalance between phases (0 = perfect balance)	Display only	N/A	N/A
	RMS Voltage 1	Measured RMS quantities for each input channel	Display only	N/A	N/A
	RMS Voltage 2		Display only	N/A	N/A
	RMS Voltage 3		Display only	N/A	N/A
	RMS Current 1		Display only	N/A	N/A
	RMS Current 2		Display only	N/A	N/A

Edit Settings Menu Group	Submenu items	Description	Type	Range	Default Value
	RMS Current 3		Display only	N/A	N/A
	Line frequency	Measured line frequency	Display only	N/A	N/A
	Phase ordering	The observed order of the connections relative to the V_1 input channel Lower case voltage, upper case current.	Display only	N/A	N/A
Harmonic Values	THD %	Total harmonic distortion of the selected input channel	Display only	N/A	N/A
	1st Harmonic %	Harmonic contents of the selected input channel	Display only	N/A	N/A
	3rd Harmonic %		Display only	N/A	N/A
	5th Harmonic %		Display only	N/A	N/A
	7th Harmonic %		Display only	N/A	N/A
	9th Harmonic %		Display only	N/A	N/A
	11th Harmonic %		Display only	N/A	N/A
	13th Harmonic %		Display only	N/A	N/A
	Signal Select	The input channel selected for harmonic measurements	Edit/ Display	$V_1/V_2/V_3$ $I_1/I_2/I_3$	I_1
	Harmonic calc	Switch harmonic calculations On/Off	Edit/ Display	ON/OFF	ON
Comm. Settings	Device address	Networking address	Edit/ Display	1-255	0
	Baud rate	Communications bit transfer speed	Edit/ Display	300-38400	19200

Edit Settings Menu Group	Submenu items	Description	Type	Range	Default Value
	Parity	Parity check	Edit/ Display	Even/Odd	Even
	Data bits	Number of bits containing data	Edit/ Display	7/8/9	8
	Stop bits	Number of bits indicating end of transmitted frame	Edit/ Display	1/2	2
	Response delay	Delay (in ms) before MCM will respond to an input command.	Edit/ Display	0 – 9	0
Motor Settings	Nominal voltage	Nominal motor phase – neutral working voltage	Edit/ Display	0.1 – 500000 VAC	230 VAC
	Nominal current	Nominal motor working current	Edit/ Display	0.1- 30000 A	300 A
	Nominal frequency	Nominal line frequency or most common inverter operating frequency	Edit/ Display	20 (5*) – 120 Hz	50 Hz
	Nominal RPM	Nominal angular speed of the motor	Edit/ Display	0 – 32000 rpm	1500
	Connection type	Motor connection type under normal running conditions	Edit/ Display	Star/Delta	Star
	Motor serial #	Optional identifier	Edit/ Display	-	m000
Calibration	V channel 1	Calibration factors for each input channel sensor	Edit/ Display	0.1-999999	1.0
	V channel 2		Edit/ Display	0.1-999999	1.0
	V channel 3		Edit/ Display	0.1-999999	1.0
	I channel 1		Edit/ Display	0.1-999999	1.0
	I channel 2		Edit/ Display	0.1-999999	1.0
	I channel 3		Edit/ Display	0.1-999999	1.0

Edit Settings Menu Group	Submenu items	Description	Type	Range	Default Value
Alarm Thresholds	Current balance %	Maximum permitted current imbalance	Edit/ Display	0 –100	20 (60*)
	Voltage balance %	Maximum permitted voltage imbalance	Edit/ Display	0 –100	10 (50*)
	Voltage range %	Maximum permitted voltage upper limit (as % above nominal)	Edit/ Display	0 –100	10 (90*)
	Max Current%	Maximum permitted current upper limit (as % above nominal)	Edit/ Display	0 –100	50 (90*)
	Low voltage %	Minimum acceptable level below which voltage is considered to be zero for line and power fault alarms (as % of nominal)	Edit/ Display	0 –100	15 (20*)
	Low current	Minimum acceptable level below which current is considered to be zero for motor not running alarm (as % of nominal)	Edit/ Display	0-100 %	15 (20*)
	Current Instability	Threshold for current variation during data acquisition. If the current variation exceeds this value, the line is considered to be unstable	Edit/ Display	0-100 %	15 (45*)

Edit Settings Menu Group	Submenu items	Description	Type	Range	Default Value
	Load threshold	Used by the phase ordering algorithm to set the loading threshold. If the ratio of actual current to nominal current is more than the value of the Load threshold (in %) then the motor is considered to be working under load and the appropriate phase ordering selected. Otherwise the motor is assumed to be unloaded	Edit/ Display	0-100 %	30
Versions	Firmware version	Release version of unit	Display only	N/A	N/A
	Database version	Database version for remote monitoring	Display only	N/A	N/A
	Algorithm	Algorithm version	Display only	N/A	N/A
	Hardware version	Hardware version information	Display only	N/A	N/A
	Type	Line or Inverter versions	Display only	N/A	N/A
	Flash	Flash type	Display only	N/A	N/A
	Power range	Whether the unit works with low (<~ 700V) Or medium/high voltage motors	Display only	N/A	N/A
	Crystal freq	System clock frequency (MHz)	Display only	N/A	N/A
Run Settings	Learn iterations	Number of iterations used in LEARN	Edit/ Display	4 – 20000	3000 (400*)

Edit Settings Menu Group	Submenu items	Description	Type	Range	Default Value
	Improve iterations	Number of iterations used in IMPROVE	Edit/ Display	1 - 20000	8000 (12000*)
	Update iterations	Number of iterations used for UPDATE	Edit/ Display	10 – 20000	1500
	Flash save rate	Number of iterations after which the flash will be automatically updated with new data. If the device is operating in a noisy environment, this value should be set to a low number to ensure minimal loss of data due to power outages, and resets etc.	Edit/ Display	1 – 1000	100

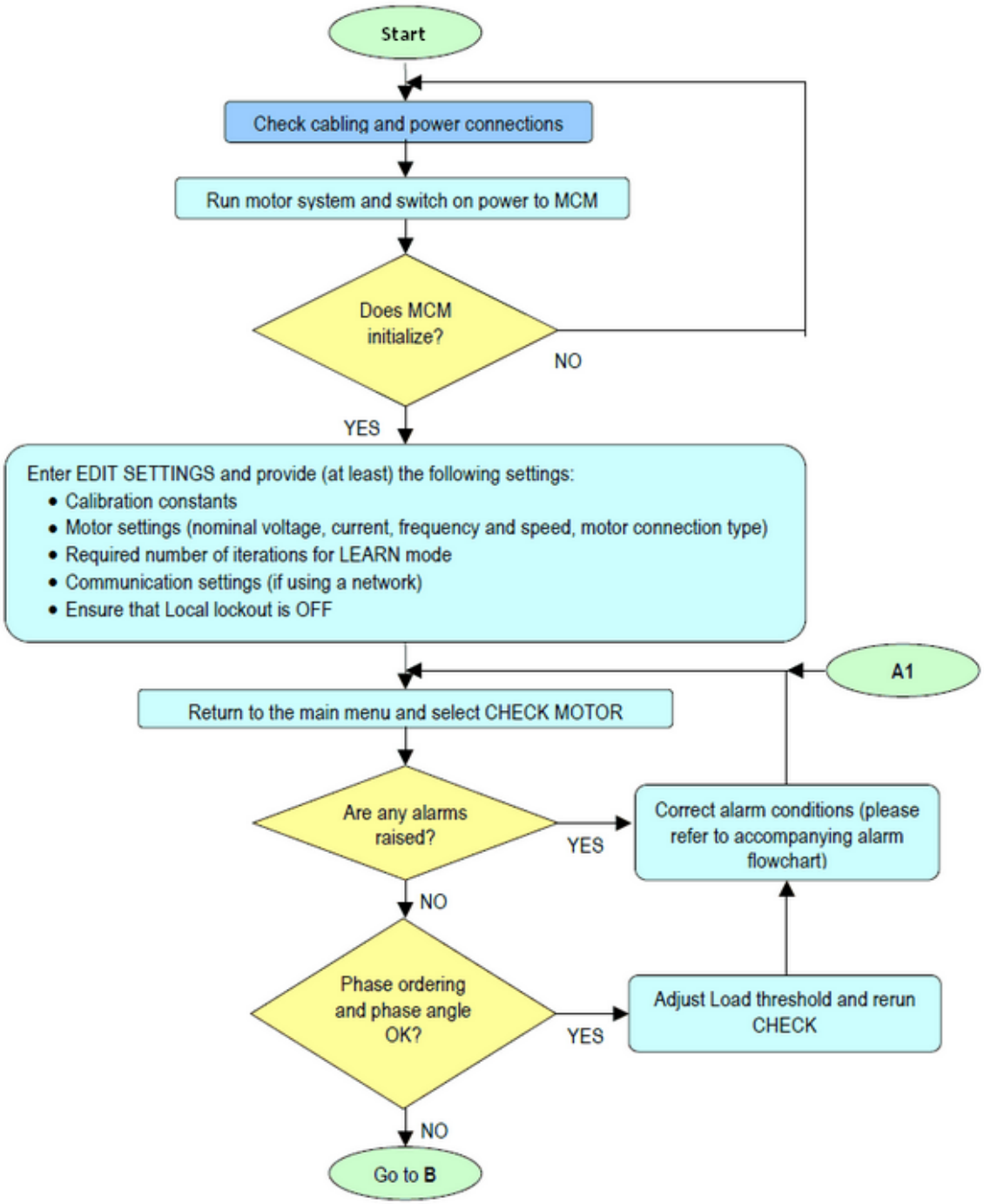
Edit Settings Menu Group	Submenu items	Description	Type	Range	Default Value
	Local lockout	Requires that passwords be supplied prior to entering all operating modes In IMPROVE/ UPDATE/ MONITOR modes only, the output relay can be set to close on the rising edge of a transition above the set fault level. The relay can be reset by selecting either **Acknowledge** or **Reset relay**. **Acknowledge** will cause the relay to close only when the current state is exceeded while **Reset** will allow the relay to close at the end of the current iteration when if the condition has not been cleared	Edit/ Display	ON/OFF	OFF
	Relay threshold		Edit/ Display	OFF WLoad? Examine1 Examine2	OFF

Edit Settings Menu Group	Submenu items	Description	Type	Range	Default Value
Phase Ordering	Phase override	Override the phase ordering determined automatically MCM during CHECK MOTOR. If set, the order can be changed manually from the following item	Edit/ Display	ON/OFF	OFF
	Phase order	The current phase ordering. Voltages are RST, currents rst. Preceding + or – indicates inversion (180º phase shift). Use UP/DOWN to edit phase at cursor	Edit/ Display		
Change password		Set a new password		N/A	N/A

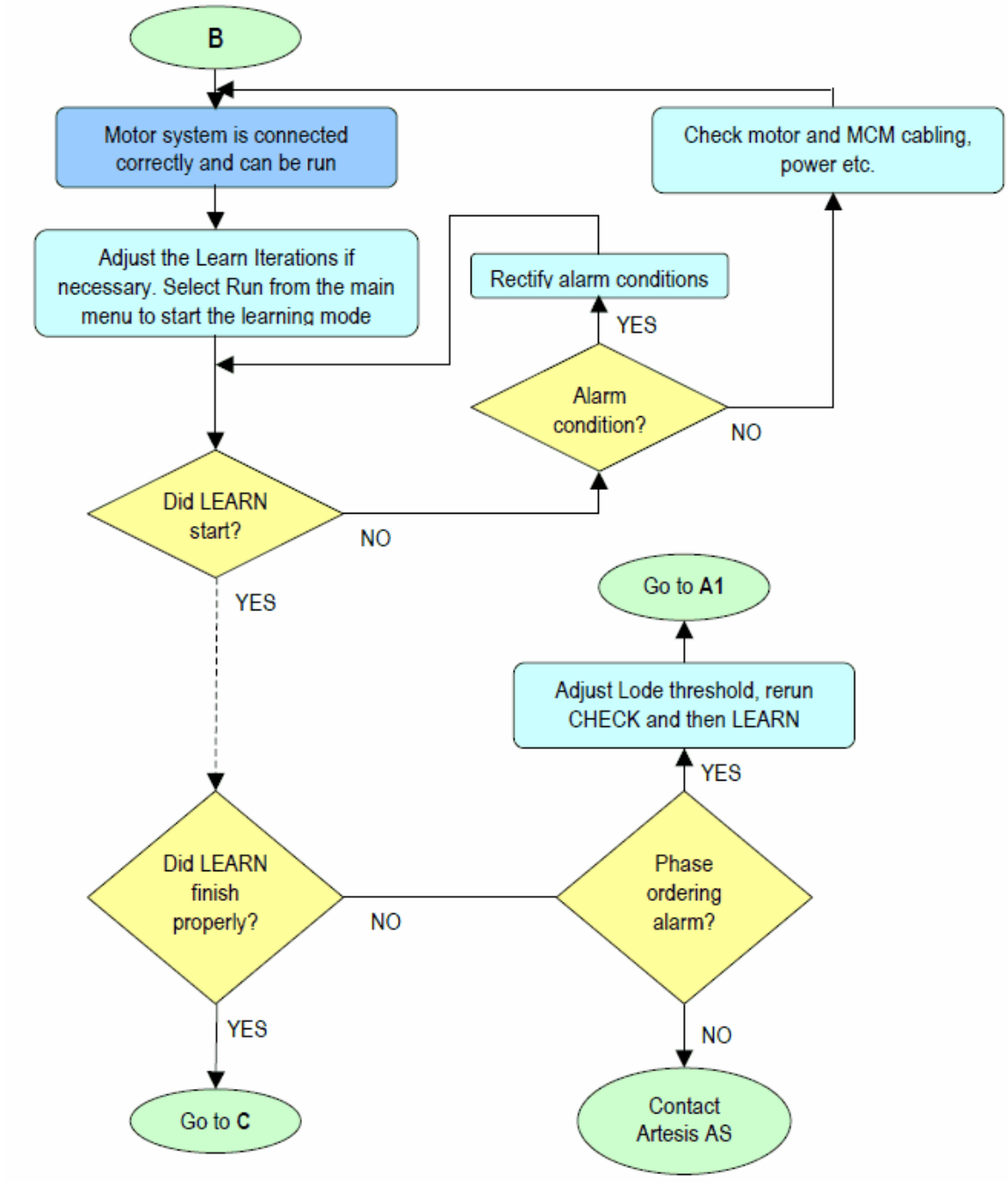
* Default values for inverter models. All the other models use default values given in the table above.

5.6 Appendix 6: Flowcharts for MCM use

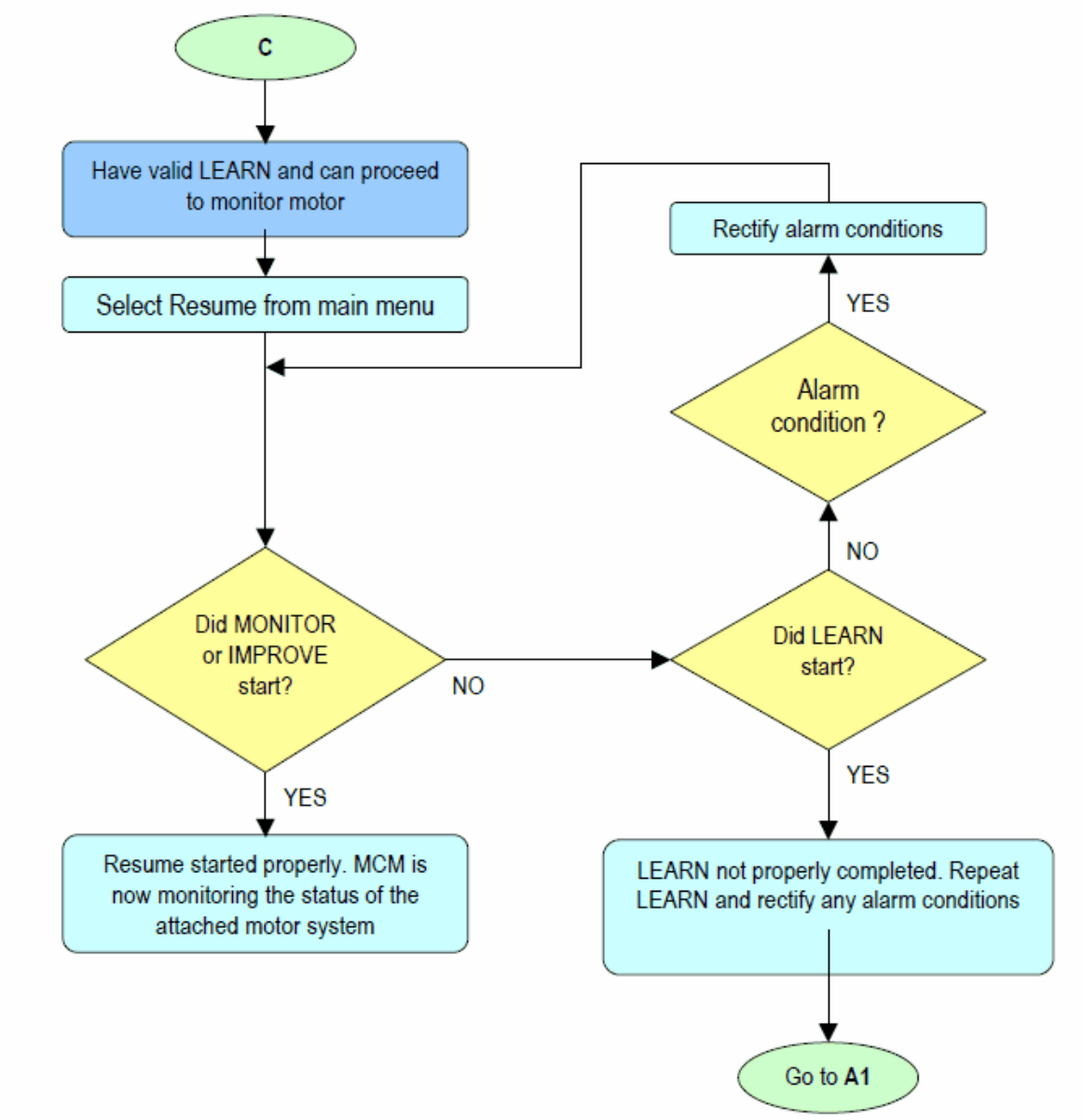
5.6.1 Running MCM: Edit Settings and Check Motor


Start
Check cabling and power connections
Run motor system and switch on power to MCM
Does MCM initialize?
NO
YES
Enter EDIT SETTINGS and provide (at least) the following settings:
• Calibration constants
• Motor settings (nominal voltage, current, frequency and speed, motor connection type)
• Required number of iterations for LEARN mode
• Communication settings (if using a network)
• Ensure that Local lockout is OFF
A1
Return to the main menu and select CHECK MOTOR
Are any alarms raised?
YES
Correct alarm conditions (please refer to accompanying alarm flowchart)
NO
Phase ordering and phase angle OK?
YES
Adjust Load threshold and rerun CHECK
NO
Go to B

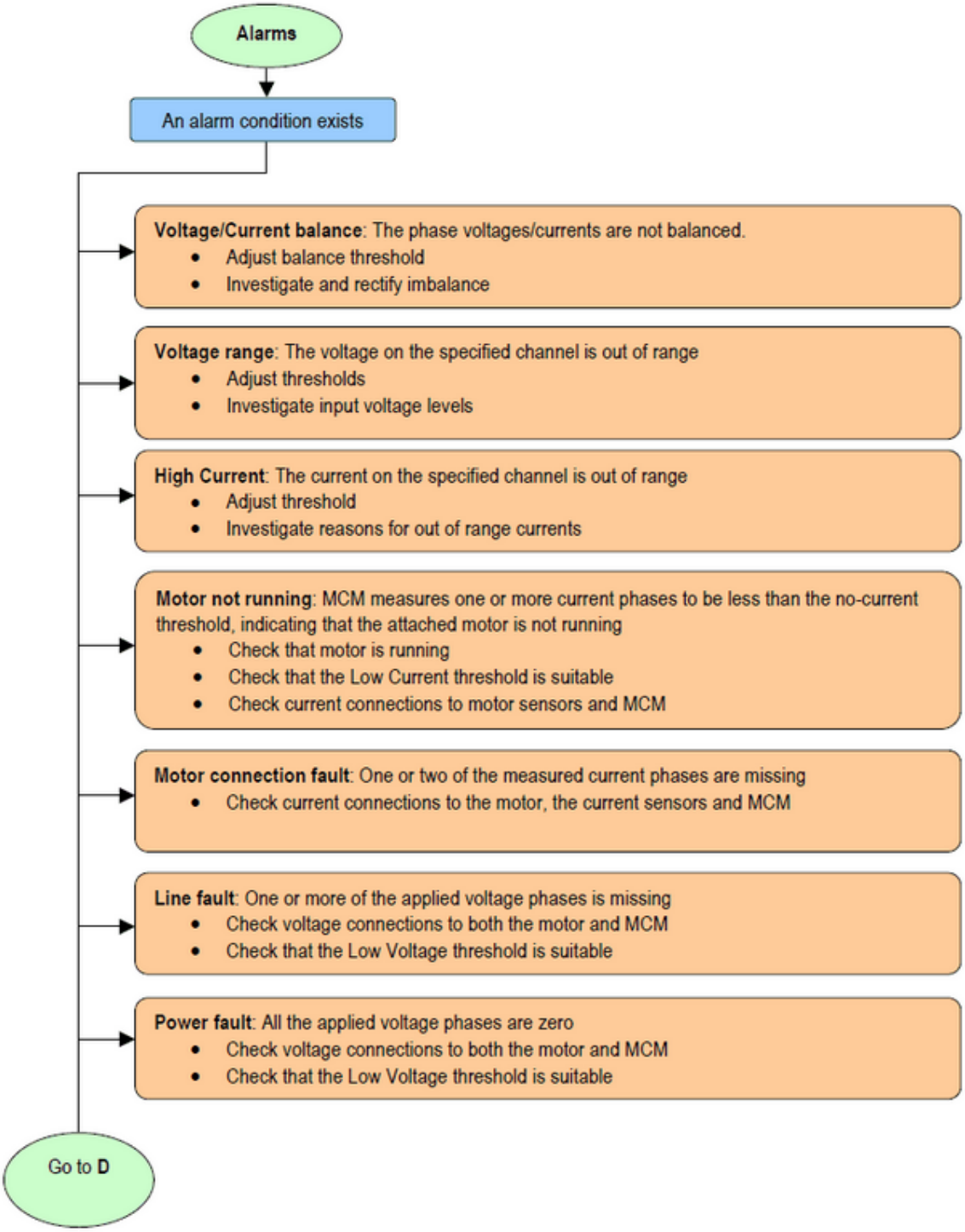
5.6.2 Running MCM: Learn

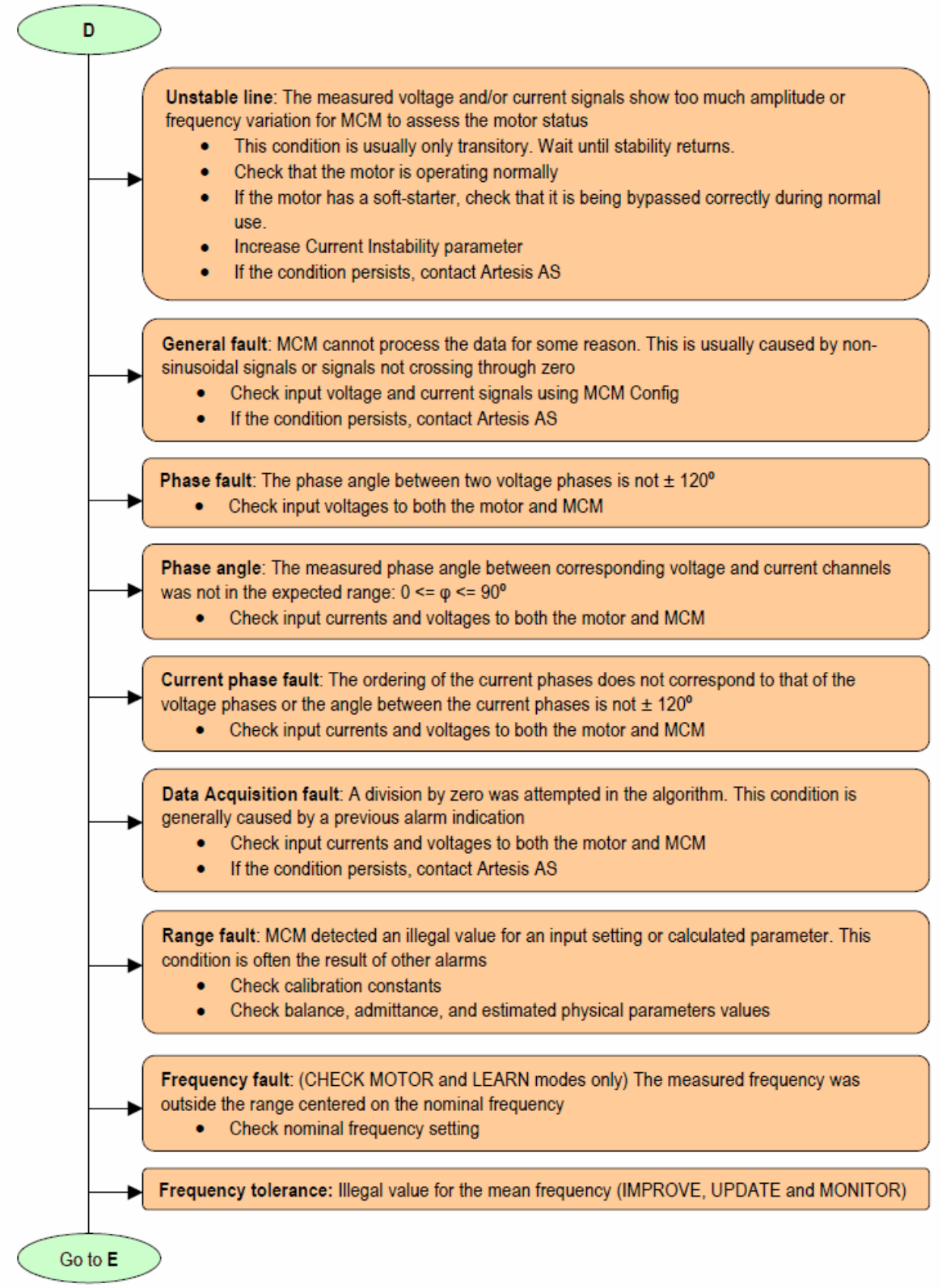


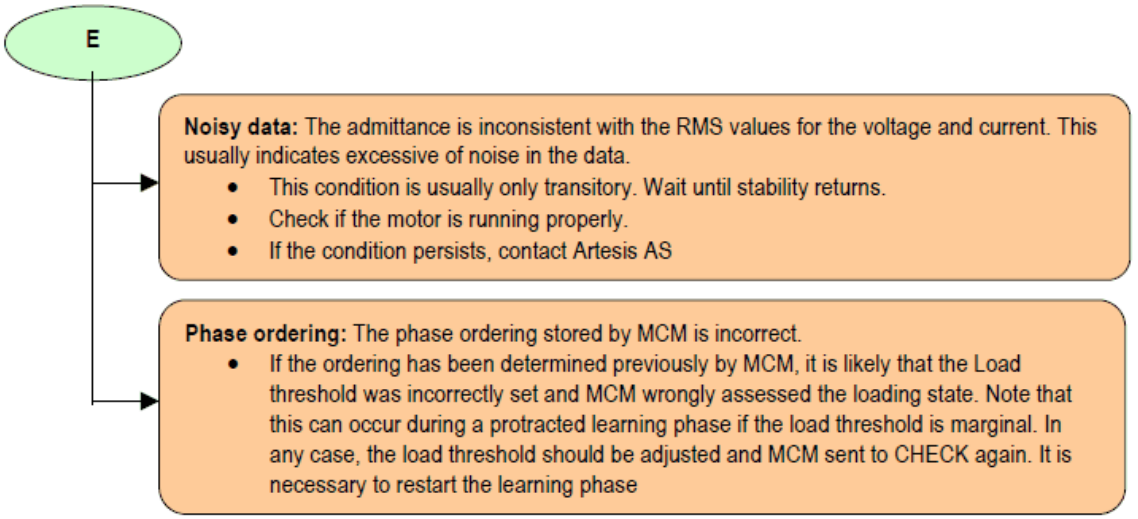
5.6.3 Running MCM: MONITOR / IMPROVE / UPDATE


C
Have valid LEARN and can proceed to monitor motor
Select Resume from main menu
Did MONITOR or IMPROVE start?
NO
YES
Resume started properly. MCM is now monitoring the status of the attached motor system
Did LEARN start?
NO
YES
Alarm condition ?
YES
Rectify alarm conditions
LEARN not properly completed. Repeat LEARN and rectify any alarm conditions
Go to A1

5.6.4 Running MCM: Alarm conditions


Alarms
An alarm condition exists
Voltage/Current balance: The phase voltages/currents are not balanced.
Adjust balance threshold
Investigate and rectify imbalance
Voltage range: The voltage on the specified channel is out of range
Adjust thresholds
Investigate input voltage levels
High Current: The current on the specified channel is out of range
Adjust threshold
Investigate reasons for out of range currents
Motor not running: MCM measures one or more current phases to be less than the no-current threshold, indicating that the attached motor is not running
Check that motor is running
Check that the Low Current threshold is suitable
Check current connections to motor sensors and MCM
Motor connection fault: One or two of the measured current phases are missing
Check current connections to the motor, the current sensors and MCM
Line fault: One or more of the applied voltage phases is missing
Check voltage connections to both the motor and MCM
Check that the Low Voltage threshold is suitable
Power fault: All the applied voltage phases are zero
Check voltage connections to both the motor and MCM
Check that the Low Voltage threshold is suitable
Go to D


D
Unstable line: The measured voltage and/or current signals show too much amplitude or frequency variation for MCM to assess the motor status
This condition is usually only transitory. Wait until stability returns.
Check that the motor is operating normally
If the motor has a soft-starter, check that it is being bypassed correctly during normal use.
Increase Current Instability parameter
If the condition persists, contact Artesis AS
General fault: MCM cannot process the data for some reason. This is usually caused by non-sinusoidal signals or signals not crossing through zero
Check input voltage and current signals using MCM Config
If the condition persists, contact Artesis AS
Phase fault: The phase angle between two voltage phases is not ± 120º
Check input voltages to both the motor and MCM
Phase angle: The measured phase angle between corresponding voltage and current channels was not in the expected range: 0 <= φ <= 90º
Check input currents and voltages to both the motor and MCM
Current phase fault: The ordering of the current phases does not correspond to that of the voltage phases or the angle between the current phases is not ± 120º
Check input currents and voltages to both the motor and MCM
Data Acquisition fault: A division by zero was attempted in the algorithm. This condition is generally caused by a previous alarm indication
Check input currents and voltages to both the motor and MCM
If the condition persists, contact Artesis AS
Range fault: MCM detected an illegal value for an input setting or calculated parameter. This condition is often the result of other alarms
Check calibration constants
Check balance, admittance, and estimated physical parameters values
Frequency fault: (CHECK MOTOR and LEARN modes only) The measured frequency was outside the range centered on the nominal frequency
Check nominal frequency setting
Frequency tolerance: Illegal value for the mean frequency (IMPROVE, UPDATE and MONITOR)
Go to **E**


E
Noisy data: The admittance is inconsistent with the RMS values for the voltage and current. This usually indicates excessive of noise in the data.
This condition is usually only transitory. Wait until stability returns.
Check if the motor is running properly.
If the condition persists, contact Artesis AS
Phase ordering: The phase ordering stored by MCM is incorrect.
If the ordering has been determined previously by MCM, it is likely that the Load threshold was incorrectly set and MCM wrongly assessed the loading state. Note that this can occur during a protracted learning phase if the load threshold is marginal. In any case, the load threshold should be adjusted and MCM sent to CHECK again. It is necessary to restart the learning phase

5.7 Appendix 7: Technical Specifications

GENERAL INFORMATION	
Net Weight	1170g (Inverter models 980g) 2.58lb (Inverter models 2.16lb)
Device Dimensions (W x H x L)	90x90x140 mm (3.54x3.54x5.67 in)
Mounting	Front Panel Mounting (indoor use)
Relay Contact Rating	30VDC, 2A, SELV
Current Connector Wire Gauge	Minimum: 30 AWG, Maximum: 12 AWG
Current Connector Screw Torque	Minimum: 0.5Nm (4.4 lb-in) Maximum: 0.6Nm (5.3 lb-in)
Voltage Connector Wire Gauge	Minimum: 30 AWG, Maximum: 12 AWG
Voltage Connector Screw Torque	Minimum: 0.5Nm (4.4 lb-in) Maximum: 0.6Nm (5.3 lb-in)
Power Supply Connector Wire Gauge	Minimum: 30 AWG, Maximum: 12 AWG
Power Supply Connector Screw Torque	Minimum: 0.5Nm (4.4 lb-in) Maximum: 0.6Nm (5.3 lb-in)
Cables of Rear Connectors	Cables must be suitable for minimum 80°C (176°F)

AMBIENT CONDITIONS	
Operating Temperature	0-40°C (32-104 °F)
Humidity	90%, non-condensing
Pollution Degree	2
Altitude	2000 m (6562 ft)
IP Rating Front	40 (whole unit IP20)

INPUT SUPPLY VOLTAGE		
The power supply voltage must be connected to the MCM unit		
Via a UL listed fuse		15A
Over voltage category		CAT II
Voltage		100-240VAC (-15%+10%), 47-64Hz, 19VA, 200mA (Use UL listed 15A fuse with proper voltage ratings)
		120-300VDC, 19VA, 200mA (Use UL listed 15A fuse with proper voltage ratings)

VOLTAGE MEASUREMENT						
Voltage transformers must meet local standards and regulations. For North America, current and voltage transformers must be certified by an OSHA appointed NRTL to appropriate UL or CSA - product safety standards. Only SELV voltage transformers must be used with MCM units.						
Over Voltage Category		CAT II				
Impedance		3.5MOhm/Phase-to-Phase				
Quantity	**Nominal**	**Minimum**	**Maximum Measurable**	**Maximum Permissible**	**Units**	**Notes (See Key)**
Voltage	480/277	20	520/300	606/350	VAC	1,2
Frequency	50/60	45	65	65	Hz	1
	50/60	25	90	90	Hz	2

KEY	
Number	MCM Version
1	MCM LV and MV Line and MCM Inverter 5/1A versions
2	MCM LV and MV Inverter Versions

CURRENT MEASUREMENT							
Current transformer and current sensors must meet local standards and regulations. For North America, current and voltage transformers must be certified by an OSHA appointed NRTL to appropriate UL or CSA - product safety standards. Max. 250VAC, CAT II for 5A and 1A units. Max. 30VAC/SELV for MCM Inverter units used with 50-400mA secondary output current sensors.							
Over Voltage Category		CAT II					
Quantity	**Nominal**	**Minimum**	**Maximum Measurable**	**Maximum Permissible**	**Units**	**Impedance (Approx)**	**Notes (See Key)**
Current	5	0.2	7	20 (For 5 s)	A	15.3 mOhm	1 (5A)
	1	0.04	1.4	4 (For 5 s)	A	50 mOhm	1 (1A)
	50	1.5	70	80 (For 5 s)	mA	50 Ohm	2 (50-100A)
	100	3	140	180 (For 5 s)	mA	25 Ohm	2 (200 – 300 - 500A)
	200	6	250	300 (For 5 s)	mA	12.5 Ohm	2 (1000A)
	400	12	500	600 (For 5 s)	mA	6.25 Ohm	2 (2000A)

KEY	
Number	MCM Version
1	MCM LV and MV Line and MCM Inverter 5/1A versions
2	MCM LV and MV Inverter Versions

5.8 Appendix 8: Compliance and Certification

EMC		
Europe	EMC Directive 2004/108/EC	EN 61326-1 Immunity for Industrial Environments
		EN 61326-1 Emissions for Industrial Environments
Australia/New Zealand	C-tick	IEC EN 61326-1 Immunity for Industrial Environments
		IEC EN 61326-1 Emissions for Industrial Environments

Electrical Safety		
Europe	Electrical Safety Directive 2006/95/EC	EN 61010-1 Safety Requirements for Electrical Equipment
Australia/New Zealand	C-tick	IEC 61010-1 Safety Requirements for Electrical Equipment
North America	UL Listed, Canada and US	UL 61010-1 Safety Requirements for Electrical Equipment

c UL US
LISTED
MEASURING
EQUIPMENT
3SG7

N1235Z

CE

Добровольная сертификация